ELECTRIC CLOCKS

Principles, Construction & Working

BY

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EDITOR'S PREFACE

THERE is an enormous demand for information concerning the principles, construction and working of electrically operated clocks, but there is surprisingly little literature on the subject to which reference can be made. What there is happens to be theoretical and descriptive, rather than practical. Here, in this handbook, an actual maker of electric clocks presents detailed instruction, accompanied by a very large number of diagrams, which will be found to provide clear and exact ideas as to how electric clocks work and as to how the amateur can make them for his own use. Every effort has been made to explain the mechanism and the methods of making and assembling it in simple language.

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ELECTRIC CLOCKS

CHAPTER I

The Principles and Working of an Electric Clock

ELECTRIC clocks are, generally speaking, of four kinds: (*a*) an ordinary pendulum clock, spring or electrically driven, whose indications are synchronised or periodically corrected by a master regulating clock; (*b*) the self-winding electric clock—that is, a clock which is spring-driven, but is automatically wound by electrical means; (*c*) the electrically-driven clock whose hands are impelled by currents of short duration at regular intervals, the impulses being supplied by a master clock; (*d*) the self-contained clock driven from a battery.

It is the two last-named with which this book deals as being of the class of most general interest. The two first are omitted entirely.

With regard to the self-driven and the impulse types of electric clocks, it is proposed to enter into their construction very fully, and it is the object of this book to enable the reader who is quite unlearned, even in the rudiments of electricity, to construct a clock that will prove most serviceable and reliable. In order to do this it will be necessary to detail a few elementary facts relating to electricity, magnetism and

mechanics, which, if thoroughly grasped, will be of great assistance in the making and maintenance of the clocks.

For the running of an electric clock some means of obtaining an electric current is required, and the most suitable is either a dry battery or a Leclanché battery, both being of the types which are used for electric bells. Properly speaking, a battery consists of two or more cells, the term for a unit being a "cell."

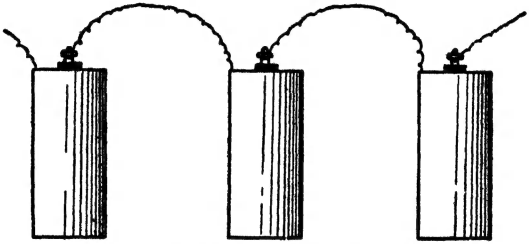


Fig. 1.—Battery of Three Dry Cells

Dry cells are purchased ready for use. The number required varies from two to six, according to the work they have to perform. It will be observed that there is on each cell a central connection (carbon, positive) and an outer connection (zinc, negative). When connecting a number of cells together a zinc is connected to the carbon of the next cell and the zinc of this to the carbon of the next, and so on. The result is a free carbon at one end and a free zinc at the other. An illustration (Fig. 1) is given of the arrangement.

As regards output and duration of life the Leclanché cell is much to be preferred, the only disadvantage

being that it is a wet cell, and therefore not suitable for placing in the clock case. Fig. 2 is an illustration of a Leclanché cell.

If matters can be so arranged that the Leclanché battery can be fitted in a cellar and a couple of wires led up to the clock, the use of these cells is strongly recommended. Leclanché cells when purchased will require charging with a saturated solution of sal ammoniac. Water is to be added occasionally to make up for loss due to evaporation. The method of connecting the cells is the same as for the dry cells. Actually the battery is the last item which will be required for the clock, but being the source of power, mention has been made of it first. The only other electrical component which requires any degree of understanding is the magnet, and this will be dealt with now.

Fig. 2.—Leclanché Cell

Supposing that a bar of soft iron is wound with a number of turns of insulated copper wire, and the wire connected to a battery—one end of the wire to the carbon and the other end to the zinc—as shown diagrammatically in Fig. 3, the piece of iron becomes a magnet, and so long as the current flows, remains a magnet; its magnetism vanishes, however, immediately the current ceases. Note should be made

that soft iron is mentioned; steel will become magnetised, but its magnetism is retained. The softer the iron the more quickly is it demagnetised, and in the construction of a clock-magnet this is a necessary feature.

Iron can only be magnetised to what is termed the

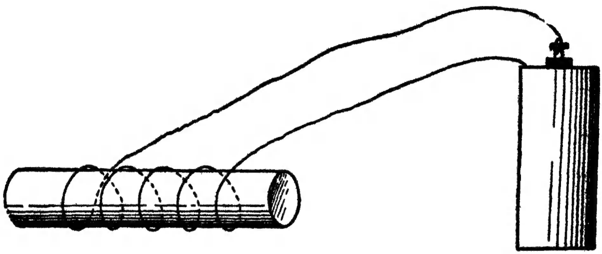


Fig. 3.—Electro-magnet

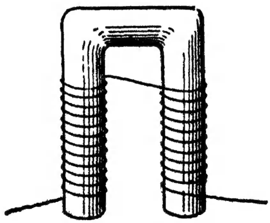


Fig. 4.- Horseshoe Electro-magnet

point of saturation, and to attain this, considerations of the number of turns of wire, its gauge, and the battery strength have to be calculated. For the present purpose it is not necessary to enter into these calculations, for the sizes and quantities, etc., are stated in the instructions, and these should be carefully observed. If the piece of iron is bent into a U shape

both poles of the magnet can be utilised, or, alternatively, instead of bending the iron the magnet can be built up of three pieces—a yoke and two pole pieces. It is essential that the wire should be wound in such a way that, if the iron was straightened out, the winding would be unidirectional, though whilst the magnet is U shaped the convolutions of wire are naturally in reverse directions. This is shown in Fig. 4.

The only other electrical item is the contact, which is, in effect, an automatic switch and is so very simple that no explanation is necessary beyond stating that the points should be of platinum. Other commoner metals soon oxidise and burn, and so the easy passage of the current is prevented. All electrical connections should be clean and bright, and wherever possible they should be soldered.

Method of Driving.—In the case of an ordinary clock, the coiled spring contains the potential energy necessary to drive the clock, and the problem of the clockmaker has been to ensure that this energy is given out at a definite rate, extending over a certain period.

The physical laws relating to the pendulum have rendered this possible. The period of a natural pendulum of a given length is always the same whatever the amplitude of its swing (slight variations occur according to distance from the equator). To give an illustration of this, a pendulum 39.13983 in. in length occupies one second in making one complete swing—a swing is reckoned as the single movement from one

side to the other. Now whether the amplitude of the swings increases or decreases, the time—one second—remains the same. It is to this physical law that we are indebted for the accuracy of our clocks.

In the ordinary type of clock the pendulum is only used as a means of controlling the output of power, and this it does with a remarkable degree of precision. The spring, via the usual train of wheels, drives the

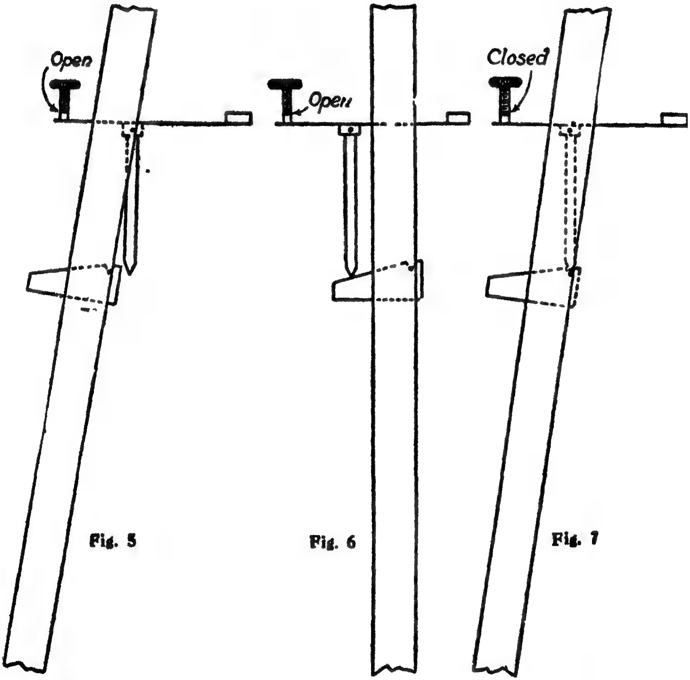


Fig. 5.—Pendulum in Full Swing. Trigger has Cleared the Block. Fig. 6.—Pendulum Stationary. Fig. 7.—Pendulum with Reduced Swing. Trigger having Caught in Notch is about to Lift Contact Spring

pendulum, giving it a slight assisting impulse each swing. In the case of the electric clock, matters are rather different. The electric pendulum does not receive an impulse every swing but only when it requires one—to give it an impulse each swing would be unnecessarily wasteful of current. Further, the electric pendulum is not driven by the wheels, but, in fact, drives the wheels. The pendulum is in itself a complete working timekeeper, the train of wheels merely serving the purpose of translating its periodic swings into terms of hours and minutes.

A clear conception of the electrical functioning of the pendulum will be of great assistance in the construction of the clock; therefore, three diagrammatic representations are given, together with explanatory text (Figs. 5, 6 and 7).

CHAPTER II

A Simple Electric Clock

THE electric clock about to be described was, with the exception of one or two parts, made from scrap Although made from scrap it will keep time with any ordinary clock. Complete in its case it is shown by Fig. 8.

In a later chapter a few elaborations and improvements are described, and the design may be altered according to the inclination of the reader, though, as stated, the clock made as at present described will be both reliable and accurate.

The clockwork consists of part of a discarded American drum clock (or an alarm clock), with the addition of a few simple parts. The pendulum is electric.

The pendulum is the real timekeeper; the wheelwork simply registers the number of swings the pendulum makes. The only strain on the wheels is that of carrying round the hands. In an ordinary grandfather clock the wheels, etc., must be strong because they transmit the power, given out by the falling weight, to the escapement, which drives the pendulum. They also, of course, register the beats of the pendulum, but are not strongly made on this account.

In this electric clock matters are different. The

pendulum is driven by an electro-magnet and drives the works, the sole function of the works being to register the beats.

The amateur who is not overburdened with tools has been particularly remembered, and consequently in several instances alternative methods of constructing various parts have been given.

Now as to the tools required. These are such things as soldering bit (a mouth blowpipe is also very useful), fine files, two or three small twist-drills, hack-saw, archimedean drill, $\frac{1}{8}$-in. and $\frac{1}{4}$-in. taps, pair of shears, pliers, and similar things found in an amateur's workshop. No lathe or drilling machine is required in making this clock. All drilling can be done with brace and bit.

A back view of the works is shown in Fig. 8A. A ratchet

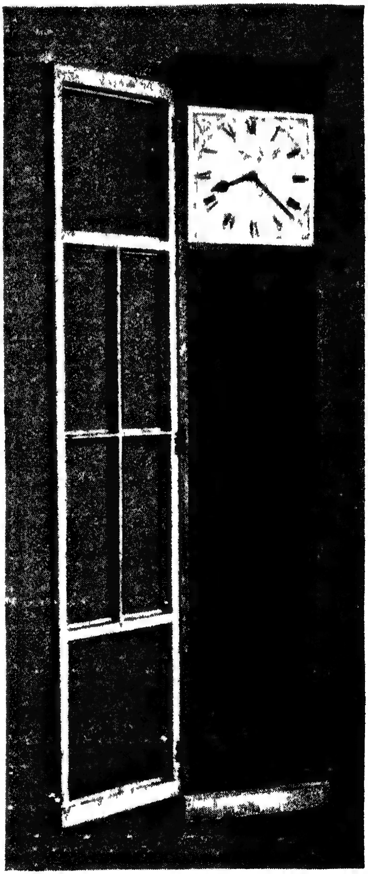


Fig. 8.—A Simple Electric Clock

wheel of thirty teeth is fitted to the seconds spindle A of the clock. The long gravity arm B fits on the spindle C. This arm has been removed and turned round to show the small rising and falling lever D. At the bottom of the arm is a piece of wire

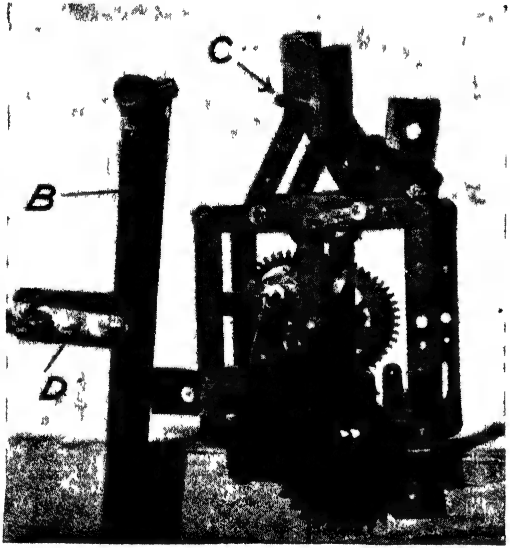


Fig. 8A.—Back View of Works with Gravity Arm Removed

projecting towards the back of the clock and engaging with the pendulum.

As the pendulum moves towards the left, the gravity arm is carried to the left, and with it the rising-and-falling lever. As the pendulum makes its return swing the gravity arm follows (by gravity, hence the name) as far as the centre line of the clock, and there waits

for the pendulum to return and move it again. Meanwhile the little lever D (Fig. 8A) has gathered a tooth of the ratchet and pushed it a step forward, and so the action goes on.

The pendulum is a seconds pendulum; that is, it swings from left to right in one second; consequently the ratchet wheel is moved one tooth forward every

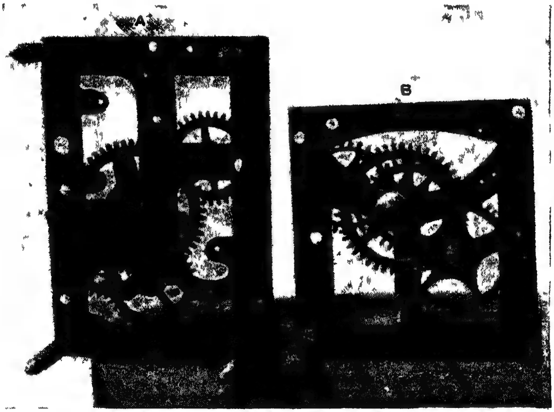


Fig. 9.—Showing Wheels Required from a Plain Drum Clock and an Alarm Clock.

two seconds. As it has thirty teeth it makes one revolution per minute.

Wheelwork.— Gather together as many old alarm or plain drum clocks as possible; this gives more choice when selecting a good one for the wheelwork of the clock, and provides material for making the various parts.

There will be required a set of works with a seconds hand, as it is to the projecting part of the seconds

spindle (after the spindle has been reversed in the frames) that the ratchet wheel is attached. Choose the longest spindle possible.

In Figs. 9, 10 and 11 the wheels required are indicated. A front view of a plain drum clock is shown in Fig. 10. On the central spindle is the wheel A, which carries the hour hand. Behind it is a small pinion B; gearing with these is the combined wheel

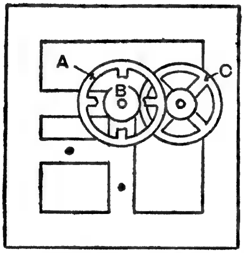


Fig. 10.—Front of Plain Drum Clock, showing Required Wheels

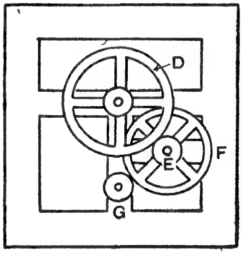


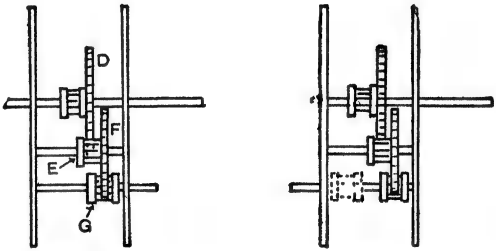
Fig. 11.—View of Wheels Inside Frames

and pinion C. These are the necessary wheels in front of the frame. An alarm clock has another wheel which sets the alarm. This should be removed.

The wheels necessary inside the frame are shown in Fig. 9. Both kinds of clock are shown (A an alarm clock, and B a plain drum clock).

The necessary train of wheels is shown in Fig. 11. On the central spindle is a wheel D, which gears with pinion E on the wheel F, and F gears with the pinion on the seconds spindle G. (Sometimes there is a wheel

on the seconds spindle as well; if so, it can be carefully removed without damaging the pinion.) Altogether, then, there are two wheels and two pinions outside the frame, and two wheels and two pinions inside. (The pinion on wheel D does not gear at all.) All



Figs. 12 and 13.—Side Views of Clock Before and After Alteration

Fig. 14.—Enlarged View of Seconds Spindle

Fig. 15.—Exaggerated Section of Bushed Hole

other wheels and parts should be laid aside. In Fig. 12 the inside wheels are shown in side view.

The next step is shown in Fig. 13. The central spindle has been sawn off at the back close to the frame, and the seconds spindle has been turned end about so that it now projects at the back, and the pinion on this spindle has been moved from the position shown by the dotted lines. This is a lantern pinion; that is, it consists of short bars of steel fitting into

two brass collars. If not handled very carefully the steel bars are easily knocked out. It will be noticed that the bars pass through one collar and into the other collar, which is thicker. To move the pinion, pass the spindle through a hole in a piece of metal) just large enough to take it easily, so that the thin collar rests on the metal. Then lightly tap the end of the spindle, and the pinion can be removed quite easily. It would be as well to practise this on a spare wheel before attempting the chosen one.

It will now be found that the spindle will not go into the holes in the frame. The ends of the spindle, as shown in Fig. 14, are not of the same diameter. One hole is too small and needs to be enlarged, and the other needs making smaller.

As it may be often necessary to enlarge holes, it may be mentioned here that if a broach or reamer is not available, the tangs of files and bradawls can be ground to serve the purpose. Knitting needles ground to a square taper and hardened do well for brass. The more gradual the taper of the reamer the better.

The hole that is too large needs bushing. Bushing wire—really fine tubing—can be had at a watchmaker's. There may be some spare part of the clock from which a bush can be made—for instance, the brass stem of the seconds hand. A section of a bushed hole (exaggerated) is shown in Fig. 15. The wire is filed to a slight taper, and the hole in the frame enlarged until the wire can be driven in. File off flush inside the frame. Hold the frame, inside downwards, firmly on the anvil, file the projecting bush

nearly down to the frame, and rivet over. The hole should have been previously slightly countersunk for this purpose. The small hole can now be enlarged to fit the spindle. If bushing is not available the hole might be enlarged to take a piece of $\frac{1}{8}$-in. wire. After fixing this as just mentioned, or by soldering, a fine hole could be drilled with an archimedean drill to take the spindle end.

Mount the wheels in position, and when all is

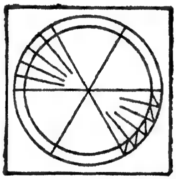


Fig. 16.—Setting Out Ratchet Wheel

Fig. 17.—Side View with Boss Fitted

correct the pinion can be fixed firmly to the spindle with a little solder. This completes the only alteration required in the wheelwork.

Ratchet Wheel.—This is filed from a piece of sheet brass from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. thick (Fig. 16). Set out a circle of $\frac{3}{4}$-in. radius and an inner one of slightly over $\frac{5}{8}$-in. radius. Divide the circumference into six parts, and each of these again into five parts. Draw the radial lines with a sharp point, and complete the backs of the teeth.

As a guide to filing, it would be as well to centre-pop each corner of the teeth; but instead of using a

centre punch use something with a much sharper point. Cut away the waste with a cold chisel, and file to a circle. The teeth should then be filed out with a fine file.

Although absolute accuracy is not necessary, the truer the teeth are to size the better. If the front of one tooth is in front of the radial line, the pawl has to be adjusted to suit that tooth; consequently there is a greater amount of "backlash" with all the other teeth, and the longer the swing of the pendulum must be.

A fine hole is drilled through the centre with an archimedean drill, and enlarged to take a bush (see Fig. 17). The brass shank of a seconds hand will do nicely if the hole is central. Solder this in place, taking care that the bush is square with the face of the wheel. The fixing can be left until later.

Extension to Frame.—To carry the gravity arm it is necessary to extend the top of the frame by two triangular pieces of brass A (Figs. 18 and 19). The spindle B is 3 in. above the spindle of the ratchet wheel. The distance piece C is a pillar taken from another clock.

If an alarm clock is used these extension pieces will be much lower, and the distance piece will not be necessary. The extensions shown in Fig. 8A can be taken from another clock frame—the central spindle of the clock serving to carry the gravity arm—so that it is only necessary to cut the pieces from the frame and rivet in position, one *behind* the front frame and the other *behind* the back frame.

The spindle which sets the alarm (if an alarm clock is being used) can easily be adapted to carry the gravity arm.

Gravity Arm.—The position of the gravity arm is shown in side elevation at D in Fig. 19, and E shows

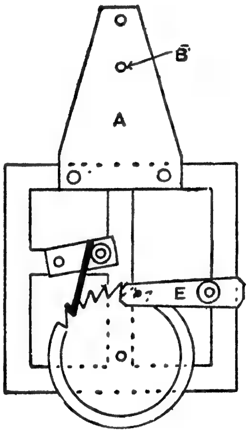


Fig. 18.—Back View of Clock

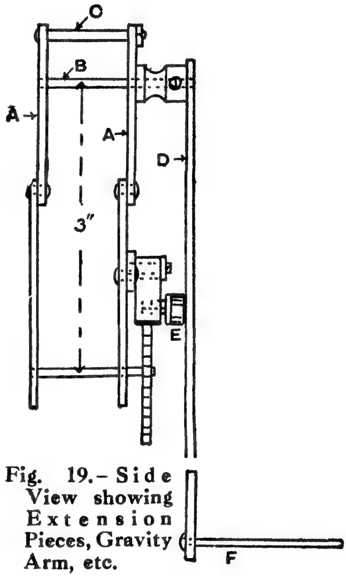


Fig. 19.—Side View showing Extension Pieces, Gravity Arm, etc.

the small rising and falling lever. Its position as seen from the back is shown at E (Fig. 18), in which illustration the gravity arm is removed.

The setting out of the gravity arm is shown in Fig. 20. This arm is made from thin sheet-brass, No. 24 gauge, roughly $\frac{1}{32}$ in. thick, the idea being to

make it as light as possible. To add the necessary stiffness it is "dished" as shown in section in Fig. 22. To do this open the jaws of the vice about ¼ in., lay the brass over the opening, and tap lightly along with

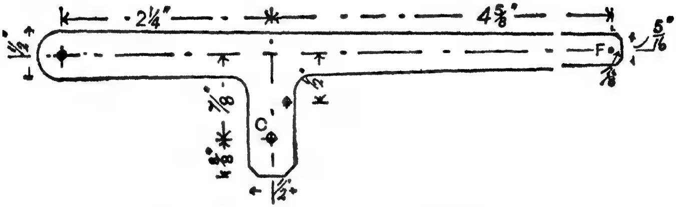


Fig. 20.—Setting Out Gravity Arm

the straight pene of a hammer. The short arm need not be dished.

Near the top of the gravity arm is soldered a round piece of brass (Figs. 21 and 22) having a hole through the centre to fit the spindle B (Fig. 19), and a set-screw in the side to fix it.

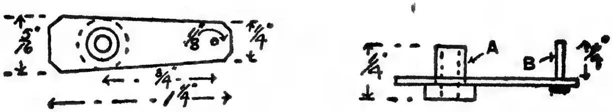
Figs. 21 and 22.—Details of Top of Gravity Arm

For this the brass knob from the top of the alarm bell can be used. The screw-hole in this knob will probably be too large for the spindle, and will need a lining of thin brass soldering in. The holes where the ring fitted can be tapped ⅛ in. to take a set-screw. Two or three suitable screws can generally be found about the clock works.

A piece of wire about 2 in. long and $\frac{1}{16}$ in. thick

is soldered into the gravity arm to engage with the pendulum. This is shown at F (Figs. 19 and 20).

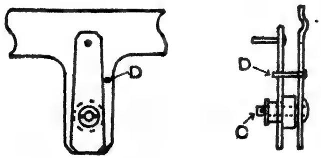
Rising and Falling Lever.—The plan and elevation of this are shown by Figs. 23 and 24. It is made from a piece of thin brass similar to that used for the



Figs. 23 and 24.—Rising and Falling Lever

gravity arm. A hole is bored through it to take the bush A (Fig. 24).

This bush was taken from the wheel which works the alarm. Solder in place. The pin B (Fig. 24) is a short length of steel hat-pin fixed with a blob of



Figs. 25 and 26.—Details of Fitting Rising and Falling Lever to Gravity Arm

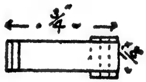


Fig. 27.—Details of Pawl

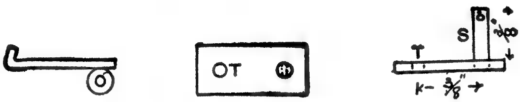
solder. This little lever is fixed to the gravity arm as shown in Figs. 25 and 26. The stud C (Figs. 20 and 26) was taken from another clock, and is the one which carries the wheel C (Fig. 10). It can either be riveted or soldered into the gravity arm. This lever should work easily but free from shake.

The position it occupies with regard to the ratchet wheel is shown at E (Fig. 18); gravity arm is removed.

To prevent the lever dropping too far and gathering two teeth instead of one, a pin D (Figs. 25 and 26) is soldered into the gravity arm. The correct position for this pin is best found by trial after the works are assembled.

Pawl.—Details of this are shown in Figs. 27 and 28. It is made from a piece of thin brass (similar to that of the gravity arm), and soldered to a piece of brass tube. This tube may be cut from the wheel which carries the hour hand (of one of the spare clocks), if the bore is suitable for the stud.

The pawl works on a stud S (Fig. 30). If available



Figs. 28, 29 and 30.—Details of Pawl

this stud can be taken from another clock along with part of the frame, and is a corresponding stud to that carrying the wheel C (Fig. 10). If desired, the pinion of this wheel may be used as the bush for the pawl.

The end of the pawl which engages with the ratchet teeth is bent over to slightly less than a right angle as shown in Fig. 31. As before mentioned, the stud (Figs. 29 and 30) may be cut from the frame of another clock. A hole T was bored about 3/8 in. from the stud to take a 1/8-in. screw.

The position occupied by the pawl is shown in Fig. 18. A hole was tapped in the frame to take the screw just mentioned. The reason for using a screw is that the pawl can be more readily adjusted. If

screwing tackle is not available it may be riveted or soldered. In that case it will be better to leave the bending of the pawl until the correct place to bend it can be found by trial.

The relative positions of pawl and ratchet are shown

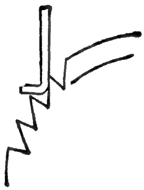


Fig. 31. Details of Pawl

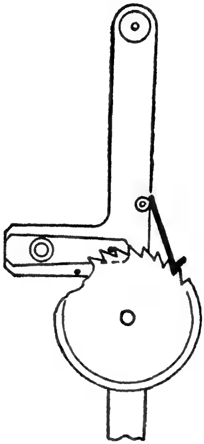


Fig. 32.—Relative Positions of Gravity Arm, Lever and Pawl

in Fig. 32, which is a front view with all the works removed.

Adjustments.—The works can now be assembled and the ratchet wheel soldered in position on its spindle. Be careful to put it on to work in the right direction.

While adjusting the rising and falling lever and the pawl, the works may be temporarily mounted on

a piece of wood (as in Fig. 8A) fixed horizontally. A stop can be fitted somewhere on the framework to prevent the gravity arm passing the centre line of the works. The correct position for the pin D (Fig. 25) can now be found, and, having fixed that, adjust the pawl.

Although not specially mentioned, washers should be used where they will assist the free working of the various parts.

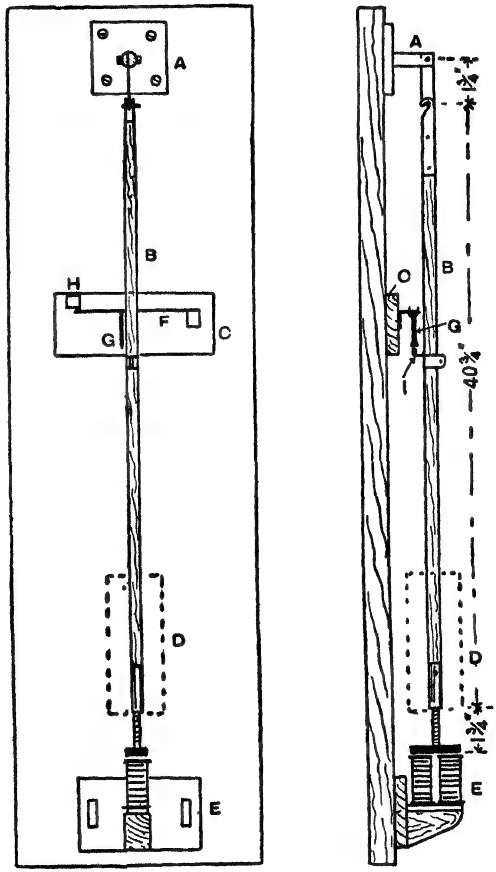
When taken from the case the works are found to be mounted on an iron ring. This ring forms a convenient means of mounting the converted clock in its new case. The ring, dial, and hands can be replaced ready for use when testing the clock with the pendulum working.

Dial and Hands.—The sizes of these can be determined later when the construction of the case is under consideration; but for convenience, a few words on making the hands will be given here. They can be made from brass, russian iron, or even stout tin; or a pair can be bought for a few pence. If bought, the holes will be too big; but that does not matter. Take the hands originally on the clock, and cut off close to the central disc. Holes are bored in the new hands to take the brass parts a tight fit, and a touch of solder will fix them firmly.

Pendulum.—This is known as a seconds pendulum, that is, it takes one second in swinging from one side to the other. Its length is, in some respects, a disadvantage, necessitating as it does a long case. On the other hand, most writers seem to agree that a long

pendulum is more conducive to accurate timekeeping than is the case with a short one.

The general arrangement of the various parts of



Figs. 33 and 34.—Front and Side Views of Pendulum

the pendulum is shown in front elevation in Fig. 33, and in side elevation in Fig. 34, where A is the suspension cock and spring, B the pendulum rod, C the contact board, D the bob, and E the electro-magnet.

The action of the pendulum is as follows: Imagine the pendulum pulled to one side and let go. It will swing to and fro with a gradually decreasing length of swing until, unless some further impulse is imparted to it, it comes to rest. Things are so arranged that when the length of swing has decreased to a certain point, a contact is closed on the contact board, the electro-magnet is energised, and an impulse given to the pendulum.

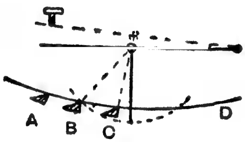


Fig. 35. Exaggerated Diagram of Action of Trigger and Steel Block

On the contact board is a horizontal steel spring F; suspended from this is a small lever, which may be called the trigger G. Projecting from the pendulum rod is a little bracket carrying a small steel block I. Filed across this block is a small notch. As the pendulum swings to and fro, the trigger slides idly over the little block so long as the swing of the pendulum is sufficient to allow of this; but eventually the swings become so short that the trigger does not clear the block. The sharp edge of the trigger engages in the little notch, and the trigger is carried back by the pendulum.

This is shown diagrammatically in Fig. 35. The little block swings in the arc D, and the trigger, normally, in the dotted arc. If the block swings to A the trigger slides over it. As the pendulum's swing

decreases, the steel block eventually only reaches the position B.

The trigger engages in the notch, and its lower end now travels in the arc D; consequently its upper end is raised, and with it the spring, which now makes

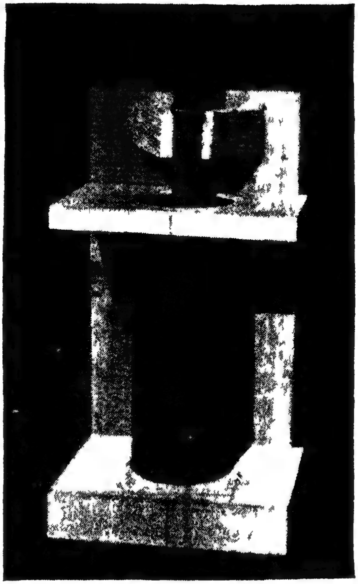


Fig. 36.—Method of Casting the Bob

contact with a set-screw, thus closing the electric circuit which energises the magnet. The pendulum receives another impulse, and so the action goes on, the pendulum only taking an impulse when required. How often an impulse is required depends on the correct "timing" of the impulse, the easy working or otherwise of the clock-works, battery, etc.

Pendulum Rod.—This, in the clock illustrated, is made from a straight-grained piece of oak ½ in. square in section and approximately 42 in. long. There is no special need to make the rod square in section, a straight-grained, hardwood dowel rod, ½ in. in diameter, would be quite suitable.

Casting the Bob.—The pendulum bob can be cast by using an empty tin about 6 in. long by 2¼ in. in diameter as a mould (care being taken that the bottom of the tin is not merely soldered in). A piece of iron 8 in. long and of the same section as the pendulum rod will be required. The tin is mounted as shown in Fig. 36.

A square hole is cut in the bottom of the tin to take the iron rod, and the bottom of the tin let into the wooden base about ¼ in. and the piece of iron about ½ in. A piece of wood is fitted round the top of the tin to act as a support. These two pieces of wood are kept in position by the back, which also carries a small block of wood to keep the iron central in the tin. The iron is further supported by wiring it to the back. Coat it with blacklead before fixing. Every care should be taken to get the rod central.

There will now be required about 9 lb. of scrap lead, and this can be melted in a ladle. Resin or charcoal should be added occasionally to prevent undue oxidisation.

Having the mould firmly fixed in the vice, pour the lead gently into the tin to prevent unsound casting. When cold the tin can be easily stripped off and the iron rod knocked out. This will form a bob about

6 in. long and $2\frac{1}{4}$ in. in diameter and weighing about 8 lb. It can afterwards be painted or cased in thin brass.

The pendulum rod should now slide easily, but without any shake whatever, into the bob.

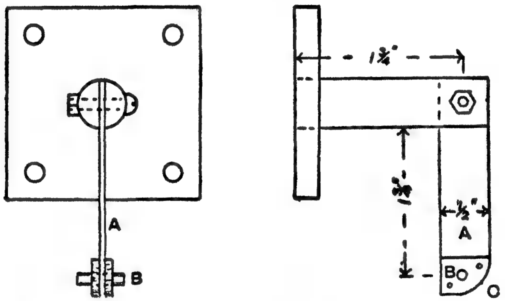
Fig. 37.—Suspension Cock, Spring and Pendulum End

Suspension Cock or Bracket.—This is shown in Figs. 37, 38 and 39 and consists of a stout back plate, say 2 in. square, and a projecting piece screwed or firmly riveted into it. The bracket illustrated is made from the plate of a broken castor, and has a piece of $\frac{1}{2}$-in. iron rod riveted into it. The end of the

iron rod is cut away to take the spring as shown in Fig. 40.

Great care is required to get this accurate, or the pendulum will not swing correctly. A new piece is required to replace the part cut away. This need not necessarily be semicircular. The matter to be careful about is to get the lower edges true; they must screw up flush. The little bolt is $\frac{1}{8}$ in. thick or a little smaller.

A much simpler suspension bracket is shown in



Figs. 38 and 39.—Details of Suspension Cock and Spring

Figs. 41, 42 and 43. It is made of two pieces of stout brass, iron, or mild steel, and bent as shown. These are mounted on a piece of hard wood. The meeting faces should be filed true, and the bottom edges flush with each other.

Suspension Spring.—This is made from a piece of corset steel $\frac{1}{2}$ in. wide, which is very thin and flexible, but can be ground even thinner. A clock repairer can supply a spring made for the purpose. Clock spring is much too thick. Two pieces of brass $\frac{3}{8}$ in. deep and

$\frac{1}{16}$ in. thick are riveted to the bottom end of the spring, one on each side. To make the holes in the steel, lay it on a piece of brass, and centre-pop it with a fine cone-pointed tool, say the tang of a file sharpened for the purpose. This will raise a burr on the underside of the steel. File this off carefully, and repeat the process. Once a hole is made it is not a difficult matter to enlarge it with a reamer. The rivets may be made from fine brass nails or brass birdcage wire.

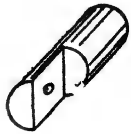
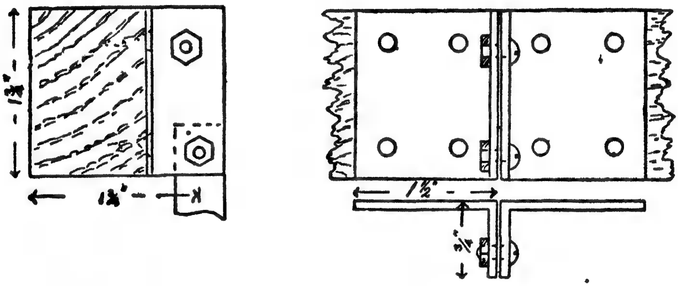


Fig. 40.—Detail of Suspension Cock

Having got the holes through the spring, lay one of the pieces of brass in position, taking care that its upper edge is square across the spring, and clamp in a hand vice. The holes can now be drilled through



Figs. 41, 42 and 43.—Alternative Suspension Bracket

the brass with an archimedean drill. The two pieces of brass can now be clamped together, and the holes made in the other piece of brass. Countersink the holes ready for riveting, and clamp together again.

The top edges of the pieces of brass must be on one

level. A parallel reamer should now be passed through the holes to ensure an even bore. Then rivet up carefully. The centre pin B (Figs. 38 and 39) on which the pendulum hangs is of brass wire $\frac{1}{8}$ in. in diameter. A hole for this might be made at the same time and to the same size as the rivet holes. This hole can now be drilled out to take the $\frac{1}{8}$-in. wire. File off the corner of the spring as shown at C (Fig. 39). A hole can then be made in the upper end of the spring to take the clamping screw.

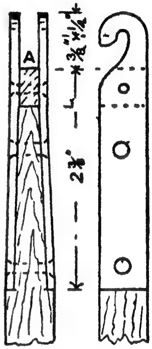
Upper End of Pendulum Rod.—The pendulum rod is suspended from the spring by means of the fitting shown by Figs. 44 and 45. It consists of two pieces of brass 3 in. long, $\frac{1}{2}$ in. wide, and $\frac{1}{16}$ in. thick, with a piece A riveted in between. The two side pieces can be clamped or temporarily riveted together for the purpose of shaping the upper end.

First bore the hole to fit the suspension pin B (Figs. 38 and 39), and then saw and file to the shape shown. Bore the holes and countersink for the rivets. The piece A is $\frac{3}{8}$ in. by $\frac{1}{2}$ in. and the same thickness as the lower end of the suspension spring. Bend the two side pieces slightly outwards. The upper end of the pendulum rod is now reduced to take this fitting, which is then riveted in position.

The rod top should fit the spring easily, but without shake.

If the pendulum rod has been made of round section, this fitting can be made of stout brass tube, or the top of the rod can be shaped to take the fitting just described.

Lower End of Pendulum Rod.—This fitting is required to carry the iron armature which swings over the poles of the magnet, and to provide a means of adjusting the height of the bob for regulating purposes. The various parts are shown in Fig. 46, where A is a piece of brass tube, B the regulating screw, C the regulating nut, D the armature, and E a nut for locking the armature.



Figs. 44 and 45. — Fitting for Top of Pendulum Rod

The brass tube is ½ in. external diameter, and fitted in the lower end is a ¼-in. iron or brass screw. The head of this screw is filed until it will enter the tube. Several saw cuts about ⅛ in. deep are made in the end of the tube. The bolt head is then pushed into the tube, and little tongues, made by the saw cuts, punched inwards to prevent the head from coming out. Pellets of solder are dropped into the other end of the tube, which is then held in the gas flame until the solder melts. A tiny hole should be drilled at F to let out the air when the pendulum rod is driven in.

The end of the rod is reduced and driven tightly into the tube, and two rivets, G and H, put through to fix it.

The length of a seconds pendulum is about 39⅛ in. from the suspension bracket to the centre of the bob. It will be better to make it a little too long rather than too short, as a packing piece can always be put

between the regulating nut and bob (if necessary), whereas the pendulum cannot be lengthened.

Fig. 34 gives the lengths of the various parts, and it will be seen that the rod (minus the screw) is $42\frac{1}{4}$ in. from the *underside* of the suspension bracket, and $42\frac{1}{2}$ in. to the suspension screw. The armature is a

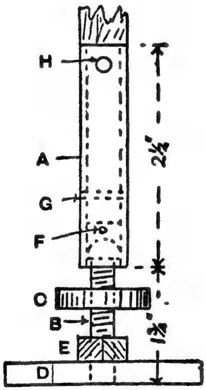


Fig. 46.—Lower End of Pendulum Rod

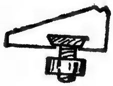


Fig. 47

Fig. 48

Figs. 47 and 48. — Details of Steel Block

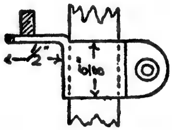


Fig. 49.—Details of Bracket

piece of soft iron 2 in. long, $\frac{3}{4}$ in. wide, and $\frac{1}{4}$ in. thick. A hole is tapped in the centre of this to fit the regulating screw.

Trigger Block and Bracket.—The trigger block is a triangular piece of steel (the broken tang of a file will do nicely) about $\frac{1}{2}$ in. long, $\frac{1}{4}$ in. high, and $\frac{1}{8}$ in. or $\frac{3}{16}$ in. thick.

A side view of this is shown in Fig. 47 and also a

plan—Fig. 48. A small V-groove is filed across the top of this, as near as possible to the top corner. This notch is about $\frac{1}{32}$ in. wide and less than $\frac{1}{32}$ in. deep. The block can be fixed on its bracket either by soldering or by means of a screw, though a small stud with a thumb nut would be the best method of fixing.

In Figs. 47 and 48 the block is shown fitted with a small screw and nut by dovetailing (the screw must

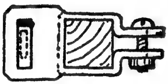


Fig. 50

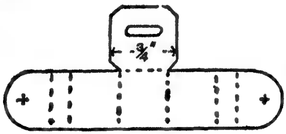


Fig. 51

Figs. 50 and 51.—Details of Bracket

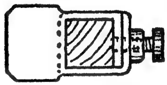


Fig. 52.—Alternative Bracket

be threaded close up to the head). The block should be tempered as hard as possible, and the slope smoothed on the oilstone.

The bracket is made from a piece of stout sheet-brass bent as shown in elevation by Fig. 49 and plan by Fig. 50. Set out as shown in Fig. 51 and bend on the dotted lines.

The piece of iron used in casting the bob can be used to bend the brass to the correct size of opening. A small nut and bolt serve to fix the bracket at the correct position on the rod.

The small slot, which is about ½ in. long and

sufficiently wide to take the little screw in the steel block, had better be left until its position can be found by trial. The slot is to allow for lateral adjustment of the steel block.

An alternative method of bending the bracket is shown by Fig. 52. The double thickness of brass at the front can be sweated together with solder, and a hole bored, tapped, and fitted with a screw; or the top of a terminal may be soldered on.

Contact Board.—This is shown in the photograph (Fig. 53) and in front elevation and plan in Figs. 54 and 55. For this there will be required a piece of hard wood, oak, mahogany, or walnut, $6\frac{1}{2}$ in. long, $2\frac{3}{4}$ in. wide, and $\frac{1}{2}$ in. thick. Slots are cut as shown at A to take round-headed screws. These slots are to allow of the contact board being adjusted laterally.

Fixed horizontally across the board is a piece of corset spring $5\frac{3}{4}$ in. long and $\frac{3}{8}$ in. wide, which is riveted to an angle piece of brass $\frac{5}{8}$ in. wide and with arms $\frac{3}{4}$ in. long, so that the spring stands $\frac{3}{8}$ in. away from the board. A piece of clock spring will do for this if ground thinner to make it more flexible. The plan of the spring (broken) is shown by Fig. 56.

Across the top of the spring is a small steel pivot (a piece of knitting needle will do) fixed in position by a small brass cap riveted to the spring. A side view of this arrangement is shown by Fig. 57.

Suspended from this pivot by a U-shaped piece of thin brass is the trigger, which is made from a piece of stout knitting needle beaten out to a chisel edge $\frac{3}{16}$ in. wide. The steel can be heated in a Bunsen

flame, and beaten out on a flat-iron. It can then be cut to length and fitted into the brass—a collar can

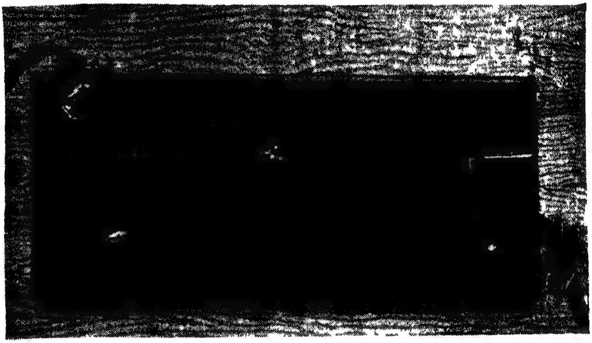


Fig. 53.—Contact Board

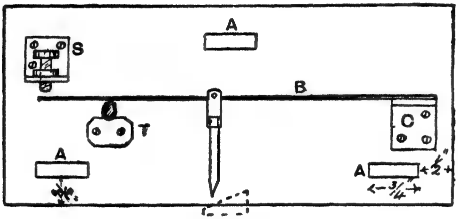


Fig. 54

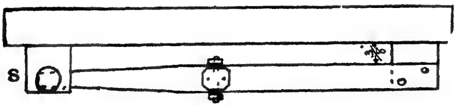


Fig. 55

Figs. 54 and 55.—Elevation and Plan of Contact Board

be added to give additional support—and soldered. The spindle should be made a nice turning fit in the holes

so that the pivot swings easily but without shake. A front elevation (Fig. 58) and a side elevation (Fig. 59) show how the trigger is built up. A better one is shown in Fig. 60. The piece of steel is fitted into

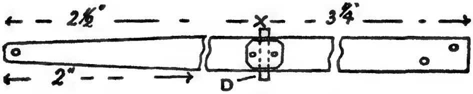
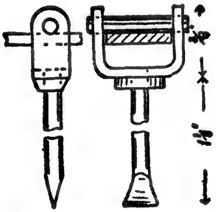
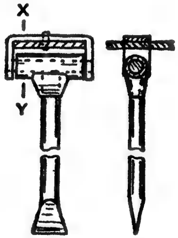


Fig. 56.—Plan of Spring (broken)

Fig. 57.—Showing Pivot and Cap



Figs. 58 and 59.—Views of Trigger



Figs. 60 and 61.—Alternative Method of Hanging Trigger

the bush taken from the wheel which sets the alarm (Figs. 62 and 63). Across the top of the bush (in a hollow filed for the purpose) is soldered a piece of tube, taken from the hour wheel of a spare clock. The end of the tube is shown in Fig. 64, and a section on X Y is shown in Fig. 61. A U-shaped piece of brass is

riveted across the spring to take the axle, which can be fixed by a touch of solder.

A contact screw S (Figs. 54 and 55) is fitted to make contact with the spring. The contact points should be of platinum. This contact may be made from a piece of brass bent to a right angle, and a nut soldered on (as shown in Fig. 65) to take any handy brass screw, or an old contact from an electric bell

Fig. 64

Fig. 62

Fig. 63

Figs. 62, 63 and 64. Showing Construction of Trigger

Fig. 66. — Support for Contact Spring

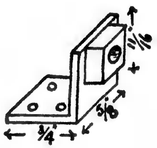


Fig. 65. — Bracket for Contact Screw

might be used. Unless the screw works very stiffly a lock nut should be provided. A support T (Fig. 54) is fitted to keep the spring horizontal. It can be bent from a piece of thin brass (Fig. 66), and a piece of felt gripped between the limbs. A round-headed brass screw covered with felt would answer the same purpose.

Electro-magnet.—The photograph (Fig. 67) shows the lower end of the pendulum rod with the bob, armature, and the electro-magnet in position. A front elevation (Fig. 68) and a side elevation (Fig. 69) show the magnet mounted on its bracket

The bracket may be of any hard wood fitted together with mortise-and-tenon joint and screwed. Terminals are fixed for connecting up the circuit, and slots are cut to allow the magnet to be adjusted for height.

The yoke of the magnet is $2\frac{1}{4}$ in. long, $\frac{3}{4}$ in. wide, and $\frac{1}{4}$ in. thick. A hole is bored in the centre to take a stout screw for fixing to the bracket. The poles are $1\frac{7}{8}$ in. long by $\frac{5}{16}$ in. in diameter, spaced $1\frac{1}{4}$ in. apart and screwed or riveted into the yoke. The bobbins are $1\frac{3}{4}$ in. long and $\frac{7}{8}$ in. in diameter, each being wound with 2 oz. of No. 26 cotton-covered wire. A horseshoe magnet is much easier to make. In Fig. 70 one is shown mounted on a bracket by means of a stout screw and a metal button.

Assembling the Various Parts.—The various parts may now be assembled temporarily on a board for trial purpose, or mounted directly on the board which is intended to form the back of the clock. Fig. 71 shows the works mounted temporarily for trial purposes. A suitable board should be 5 ft. long and 8 in. wide, and not less than 1 in. thick. Draw a centre line down the board, and fix it to a wall or other firm support by a stout screw near the top.

After the suspension bracket is fixed and the pendulum hung on, the board can be set plumb by noting when the centre line of the board coincides with the centre line of the rod, and the distance between the pendulum rod and the backboard is the same at top and bottom. Of course, great care must be exercised in doing this, or the suspension spring may

be damaged. The suspension spring itself must be fixed vertically, or it will not bend evenly.

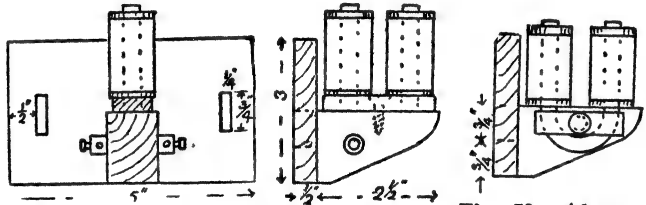
Having got the board plumb, the magnet can be

Fig. 67.—Pendulum Bob, Armature, Magnet and Bracket

fixed centrally under the rod, leaving a space about the thickness of a postcard between the magnet poles and the armature.

The contact board is fixed so that the knife edge

is 13 in. from the lower edge of the suspension bracket. It is now an easy matter to find the position of the steel block on its bracket, and the little slot can be cut or the block may be soldered on. The slope is to the left of the clock. The contact board can then be adjusted sidewise, so that the edge of the trigger is about $\frac{3}{8}$ in. to the left of the little notch.



Figs. 68 and 69.—Front and Side Elevations of Magnet on Bracket

Fig. 70. Alternative Magnet

The position of the block is shown in dotted lines in Fig. 54.

Electrical Connections.—The ends of the magnet wires are connected to the terminals provided on the bracket. From one terminal a wire passes to one of the three screws on the contact-screw bracket. Another wire from the other terminal is connected to one pole of the battery. From the other pole a wire is carried to one of the three screws on the bracket to which the spring is riveted.

Battery.—Two or three dry cells will drive the clock, and they can be placed inside the clock-case (suitable

cases are described in a later chapter). Should Leclanché cells be used the best position for them is in a cellar or other cool place as near the

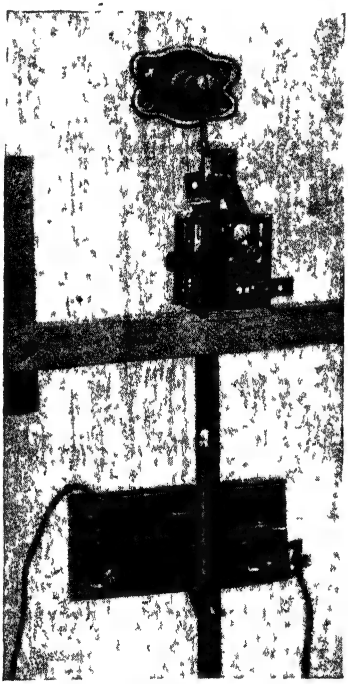


Fig. 71.—Front View of Works Mounted Temporarily for Testing Purposes

clock as possible and connected to it by a couple of wires.

Adjusting the Pendulum.—The length of swing which the pendulum must take depends on where the

the higher the point of contact the longer must be the swing, and vice versa. If the little lever is being carried farther than necessary to gather the next tooth of the ratchet wheel, the swing of the pendulum should be shortened.

Approximately the measurements are as follows: The little notch in the steel block is about $\frac{1}{8}$ in. to the right of the centre line of the pendulum. The trigger edge is about $\frac{3}{8}$ in. to the left of the notch and about $\frac{1}{8}$ in. lower; the swing of the pendulum (centre line) is about $4\frac{1}{2}$ in., and the contact screw is about $\frac{1}{16}$ in. from the spring contact. By moving the contact board to right or left the swing is lengthened or shortened, and by raising and lowering the steel block the instant and duration of contact are altered.

The best position is found by trial and noting the number of swings per impulse in the various positions. The instant the contact is made should be just the time the armature comes within the range of the magnet, and the contact should be broken again before the armature is over the core, or the swing will be retarded. A quarter turn of the contact screw makes a difference.

If the impulse is too strong the pendulum will quiver, which is not conducive to good timekeeping, and a number of weak impulses drains the battery.

An impulse every half-minute when the works are running is a suitable period. This pendulum takes an impulse when it requires one; that is, when the swing is decreasing. The rate of decrease depends on the power required to drive the works. As this

varies from time to time, so the pendulum varies in taking an impulse; thus the counting of the beats may be 22, 24, 26, 30, etc., seconds per impulse. With the pendulum running free from the works, the figures should be about double.

In later chapters will be found described other and, in some cases, more elaborate mechanisms, but the clock here described is typical of the simplest possible construction

CHAPTER III

A Three-quarter-seconds Clock with Chime Release

In the construction of a three-quarter-seconds clock much of the work will be found to be a repetition of that described for the construction of the one-seconds-clock. Some minor details of making are omitted, but these are all dealt with in the preceding chapter. The principle is the same and the method of construction is just as simple; also the tools required are the same.

With this clock there is a device for starting electrically a set of electrical chimes. The chimes are described in a later chapter.

Wheelwork.—Fig. 72 gives a general idea of the arrangement of the various parts of the clock without going into minute details; the details of each part will be found in later illustrations.

A summary of the principal parts is given here for convenience: A the backboard, 3 ft. long, 9 in. wide, and 1 in. thick, of well-seasoned wood, hard wood for preference; B the sides, 3 ft. long, $5\frac{5}{8}$ in. wide, and $\frac{1}{2}$ in. thick, of any wood; C the top and bottom, 9 in. long, $4\frac{5}{8}$ in. wide, and $\frac{5}{8}$ in. thick; D the door, 3 ft. long and 10 in. wide, the dial opening being $7\frac{3}{4}$ in. square; E the dial board, 8 in. high, 9 in. wide, and $\frac{3}{8}$ in. thick.

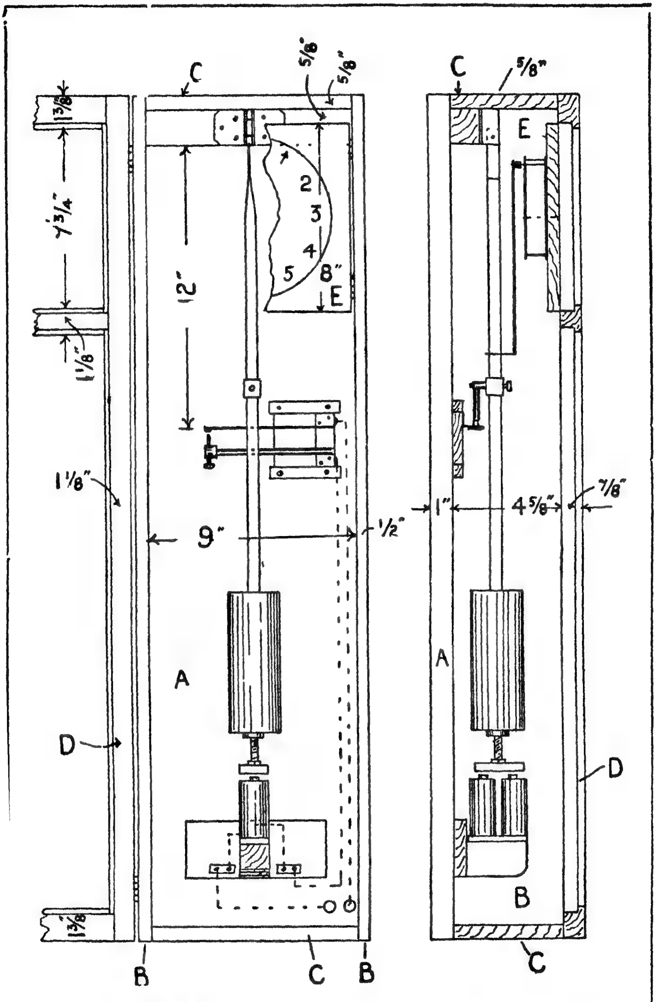


Fig. 72. – Key Diagram of Three-quarter-seconds Electric Clock

Note how D and E are hinged. This gives just the plain box-like case; mouldings can be added as desired.

The corners of the case can be dovetailed together if desired.

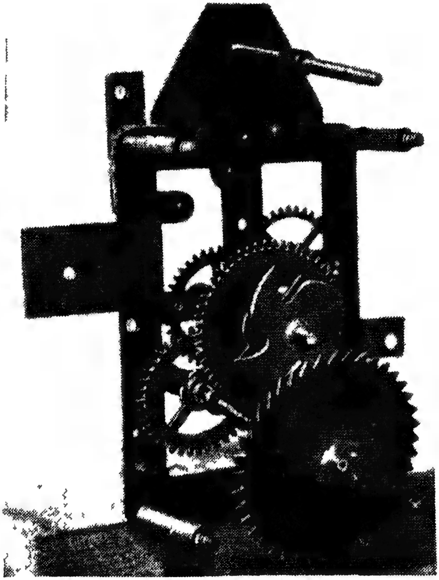


Fig. 73.—Wheelwork of Converted Alarm Clock

A stout hanger should be provided on the top of the backboard for hanging purposes, and a small plate at the bottom to prevent the clock from being pushed sidewise. The case should be fixed to the backboard with screws, as it is very convenient to have the backboard clear when fitting the various parts, and to give the pendulum a trial run for, say, a week.

For the works (see photographs, Figs. 73 and 74) a small drum clock with or without an alarm is required. The latter will serve if it is not wished to add the chime release; but the former is preferable if adding the release, as the works are taller.

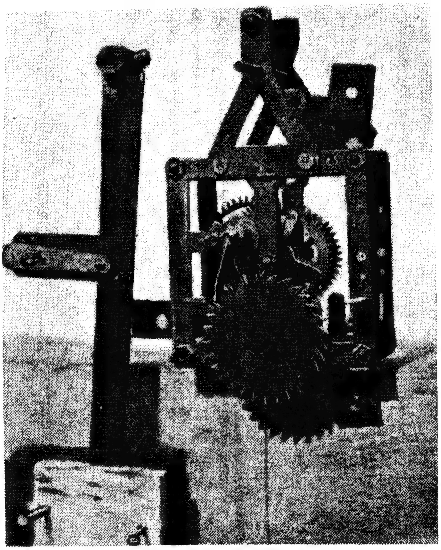


Fig. 74. Plain Drum Clock with Gravity Arm Removed

The clock must indicate seconds, because it is to the seconds spindle that the required ratchet wheel is attached (see Figs. 76 and 77).

Only four wheels and four pinions are required for the works. Of these, two wheels and two pinions which work the hands are on the front of the frame,

and need no illustration. The remainder are shown in Fig. 76.

On the central spindle 1 is a large wheel 2 (its pinion does not gear) gearing with an intermediate pinion 3. Attached to this, or on the same spindle, is the intermediate wheel 4, which gears with the pinion 5 on the seconds pinion 6.

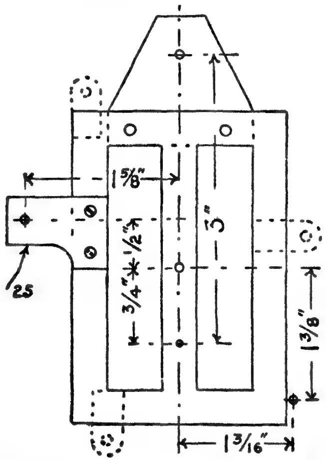


Fig. 75.—Outline of Clock Frame showing Relative Positions of Various Parts

The clock-works vary somewhat in the arrangement of the wheels, but no difficulty will be experienced in determining which are the required wheels. All the other wheels can be discarded.

The next step is to reverse the seconds spindle 6 in the frames, so that it projects at the back (see Fig. 77). To allow of this the hole in the back frame will need enlarging, and the hole in the front frame will need "bushing."

A simple way to do the latter is to bore out the hole to $\frac{1}{8}$ in., solder in a piece of brass wire, and drill a central hole to fit the spindle. The pinion 5 will not gear with its wheel now, so must be moved along

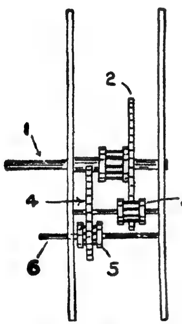


Fig. 76. Side View of Works

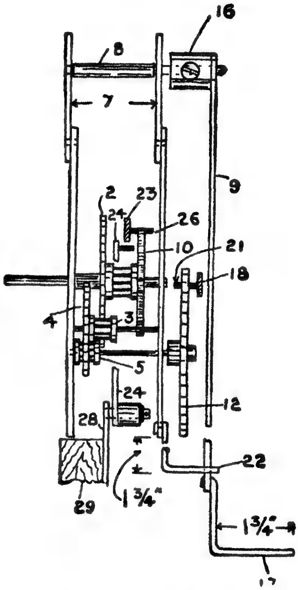


Fig. 77. Side View showing Position of Wheels for Clock with Chime

the spindle until it does. The danger in doing this is that the little bars may be displaced. Pass the spindle through a small hole in a piece of stout brass held in the vice, and tap the spindle lightly with a hammer, taking care not to bend it; solder the pinion in the new position (see Fig. 77).

Cut off the end of the central spindle 1 close to the back frame, rivet on the two extension plates 7 (Figs. 75 and 77), add a spindle 8 to carry the gravity arm 9, and solder three lugs (shown dotted in Fig. 75) to the front of the front frame.

If the plain drum clock-work is used the extension plates will require to be longer than shown in Figs. 75 and 77 to give the necessary 3 in. between the spindles 6 and 8.

This completes the alterations to the works if the chime release is not required. It is possible to add the release to the works as at present arranged, but for convenience of inspection it is advisable to make the following alterations as shown in Fig. 77. Reverse wheel 2 on its spindle, and shift pinion 3 to gear with it; solder wheel 2 in position, and solder the four-armed cam 10 to the side of the pinion. A $\frac{1}{8}$-in. or $\frac{3}{16}$-in. space between the cam and the back frame is all that is required; that is, there must be just sufficient space here to ensure that pin 26 does not touch the front frame. Space saved here will mean less cramping of the pinion 3 and wheel 4.

Ratchet Wheel and Pawl.—The ratchet wheel 12 is $1\frac{3}{4}$ in. in diameter, $\frac{1}{16}$ in. thick, and has 40 teeth barely $\frac{1}{16}$ in. deep. It can be set out on sheet brass as shown in Fig. 78, and the teeth cut with a file, cutting them as accurately as possible, because if one tooth projects farther than the others it means more work for the pendulum.

Some kind of a bush or hub should be provided, so that the ratchet wheel gets a firm seating on the

spindle. If the hub is a tight fit on the axle, it will probably be sufficiently firm for the work it has to do; if not, it can be fixed with solder.

The pawl 14 is a piece of thin brass, one end of which is thickened by soldering on a tiny piece of

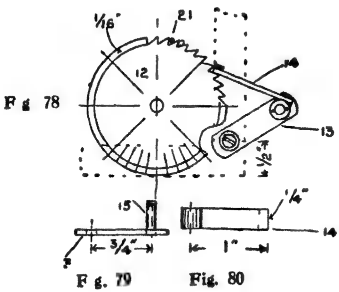
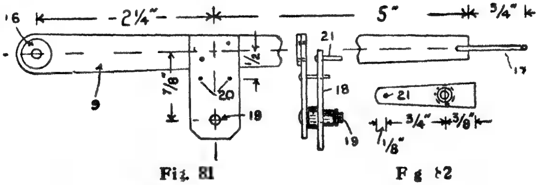


Fig. 78.—Ratchet Wheel and Pawl

Fig. 79.—Side Elevation of Arm 13

Fig. 80.—Plan of Pawl



Figs. 81 and 82.—Gravity Arm and Falling Lever

brass, and the other end is provided with a hub—a piece of tube or a pinion from a wheel—which works on a stud 15 on the adjustable arm 13.

This arm (Figs. 78 and 79) is attached to the back frame of the works—shown dotted in Fig. 78—by a short screw, so that the pawl rests on the back of about the 6th or 7th tooth.

Gravity Arm.—The gravity arm 9 is cut from sheet

brass, a little thinner than the frame of the clock, either in a solid piece or built up as shown in Fig. 81.

At the upper end is a brass hub 16 provided with a set-screw to fix it to the spindle 8. At the lower end is a piece of wire $\frac{1}{16}$ in. thick shaped as in Fig. 77.

A small rising-and-falling lever 18 works on a stud 19 between two pieces of ordinary brass pin 20. Near one end of this lever is a small steel pin 21 (Fig. 82)—a piece of hat-pin or a gramophone needle—about $\frac{1}{4}$ in. long, which engages the ratchet wheel teeth. The end of the lever containing the pin should be just a little heavier than the other end.

The action of the gravity arm can now be traced. Normally this gravity arm hangs vertically. As the pendulum swings to the left it comes in contact with the wire 17, and carries the gravity arm and the attached rising-and-falling lever to the left, so that pin 21 is drawn off the back of one tooth and dropped on to the back of the next.

One or two points should be carefully noted. The gravity arm should only be carried sufficiently far to the left (right in Fig. 78) to allow the pin to drop on to the tooth below. It will be seen now why one projecting tooth will cause a longer travel of the pendulum. If pin 21 should be carried too far it would drop, perhaps, two teeth. To prevent this the lower pin 20 can be bent to the required position, while the upper pin, which is not absolutely necessary, prevents the lever from being thrown right over in case of a jerk, etc.

The pendulum, having moved sufficiently far to

the left to allow the pin 21 to gather one tooth, starts its return swing, the gravity arm follows it (by

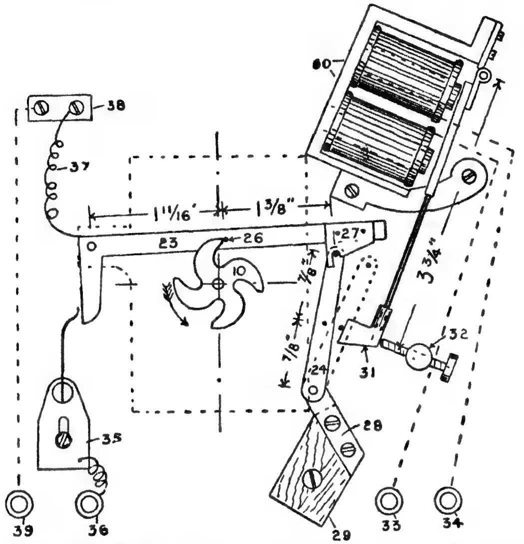


Fig. 83.—Back View of Complete Chime Release

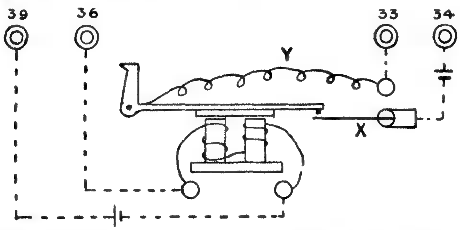


Fig. 83A.—Application of Chime Release to Chime Magnet

gravity), and by means of the falling lever carries the ratchet wheel forward one tooth, and the pawl 14 drops one tooth.

To prevent the gravity arm from going past the centre line or vertical, a piece of wire 22 can be soldered to the back frame. As the pendulum continues its swing to the right it leaves the gravity arm behind, and picks it up again on its next journey to the left.

The gravity arm should not be heavier than is necessary to propel the wheelwork; a little solder can be added near the end of the projecting limb to give weight, if necessary. Bending either wire 17 or 22 slightly to the right will have the same effect as lengthening the swing of the pendulum; but the practice is not advised.

If killed spirits (zinc chloride) be used in soldering it will be as well to steep the parts, after soldering, in a strong solution of washing soda, and then dry them thoroughly as an aid to the prevention of rust.

This completes the parts of the works so far as the ordinary mechanism is concerned, and the chime release will next be dealt with.

Chime Release.—A view of the chime release, from the back, is shown in Fig. 83. By comparing the dotted outline with Fig. 75, the positions of the various parts can be seen as viewed from the back, and again by comparing Fig. 83 with Fig. 77 it will be seen how the three principal parts are disposed to prevent them rubbing against each other, except at the desired points (see photographs, Figs. 84 and 85).

The position of cam 10 is fixed, and the contact lever 23 works just behind it, say $\frac{1}{8}$ in.. and the lifting

lever 24 works, say, $\frac{1}{8}$ in. behind this. Two lugs or brackets 25 (Fig. 75) are fitted to the frame; the one on the back frame is provided with screws, and a shouldered axle, about $\frac{1}{8}$ in. thick, is fitted between them to carry lever 23.

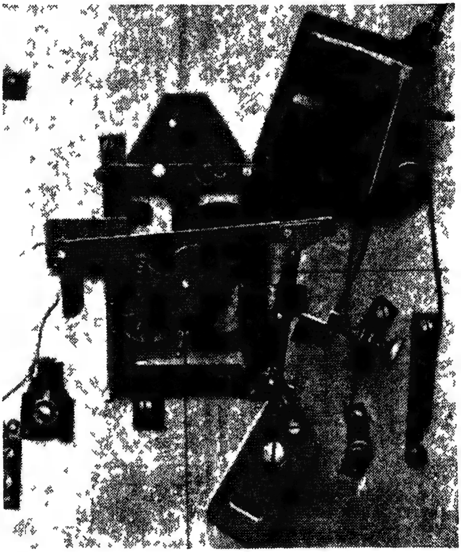


Fig. 84.—Back Removed to show Chime Release

The contact lever has an overall length of about 4 in., is $\frac{1}{4}$ in. wide, and $\frac{1}{16}$ in. thick; the short arm, 1 in. long, can be soldered to the long one to save material. A strip of silver is soldered on the back edge of this arm to form a contact strip. Fit a tight collar on the axle, slip on the lever, and another collar after it. This admits of the lever being adjusted, and

helps to keep all square; when correct, solder together and add a silver strip.

A piece of gramophone needle 26 is ground to a **D**-shape, driven tightly into a hole where shown, and securely fixed with a blob of solder on the back. The

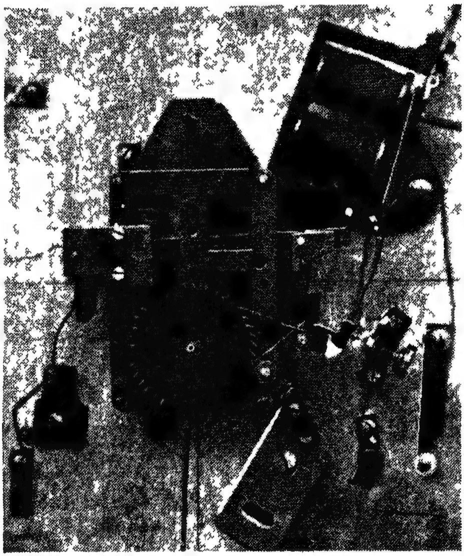


Fig. 85. – Complete Chime Release

small piece of brass 27 is shaped as in Fig. 86, and is riveted to the lever; the sloping edge should be burnished.

The lifting lever 24 is a piece of thin brass with a hub soldered on near one end, and two short pieces of gramophone needles firmly fixed where shown. This lever turns on a stud which projects from a strip of

brass 28 The brass is screwed to a piece of wood 29, which is fixed to the baseboard by one screw so as to allow of adjustment. A short slot in the wood would be an advantage.

The cam is of brass $1\frac{1}{8}$ in. in diameter and about $\frac{1}{16}$ in. thick. The setting out can be gathered from Fig. 87. This is for a quarter-hour chime; for a half-hour chime it is only necessary to cut off two opposite arms, or for a one-hour chime to leave off three.

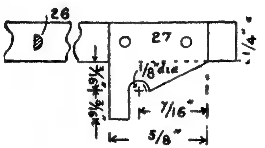


Fig. 86.—Details of Contact Arm of Chime Release

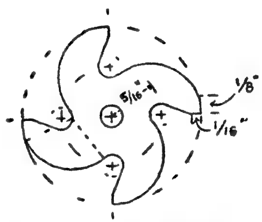


Fig. 87.—Setting Out Cam for Quarter Chimes

For accurate chiming the "falling-off" edges of the cam must be spaced equidistantly, that is, on the two diameters, which must be exactly at right angles with each other. Practically all of the original diameters are cut away, just sufficient being left to form a filing guide. A small portion of the original circumference is left for a similar reason. To effect a sudden fall the pin 26 is made D-shaped.

Chime Release Electro-magnet.—The electro-magnet can be obtained from a good electric bell. Part of the metal frame is cut away, and the armature spring

replaced by a portion of a brass hinge, which is riveted to the armature and fixed to the frame by the two screws. The hinge should work freely but without wobble.

The hammer head is replaced by a thin piece of brass 31, part of which is bent round and soldered to the shaft. An adjustable stop 32, somewhat like the contact screw of a bell, should be fitted to regulate the throw of the hammer. The hinged end of the armature should be fitted as close to the face of the magnet core as possible.

For those who wish to build their own magnet the following suggestions are given: The cores should be about $1\frac{3}{8}$ in. long and $\frac{5}{16}$ in. or $\frac{3}{8}$ in. thick; the bobbins $\frac{7}{8}$ in. in diameter, and wound with No. 24 S.W.G. wire.

The best position for fixing the magnet can be found by trial, and the ends of the magnet wires led to terminals 33 and 34.

The contact 35 is a piece of watch-spring 1 in. long, tipped with silver and supported on a pillar at a suitable height to engage the contact lever. The pillar has a brass foot provided with an adjusting slot, and has a wire soldered to it to connect it to terminal 36.

A spiral of flexible wire 37 is soldered to the end of the contact lever and led to a brass plate 38, and so arranged that it does not interfere with the free movement of the contact arm. From the plate 38 a wire is led to terminal 39.

To mount the parts shown in Fig. 83 requires a dial board at least 8 in. square and about $\frac{3}{8}$ in. thick—

two pieces of $\frac{3}{16}$-in. three-ply glued together will do nicely. An opening is cut to make room for the wheels on the front of the frame, and the frame screwed to the board by means of the lugs.

How the Chime Release Works.—In Fig. 83A is shown the magnet which starts the chimes. It will be noticed that the arm which carries the armature has been extended to the right and a contact point added. Just below this is a contact spring X built on similar lines to contact 35, and a flexible wire Y has been carried to a convenient terminal. The wiring is shown in dotted lines, and the numbered terminals correspond with those of Fig. 83.

The action throughout can now be followed The cam 10 revolves in the direction of the arrow (see Fig. 83) until in about eight minutes' time the next arm comes in contact with pin 26, and as the cam revolves it gradually raises the arm 23 and allows the lever 24 to drop, by gravity, to the position shown in dotted lines. The "warning" sound given out by the falling lever is equivalent to the "warning" of a grandfather clock just previous to striking.

The cam continues its revolution and at last the pin drops off the edge, and this allows the arm 23 to come in contact with the spring of 35. This closes the circuit of the battery connected with the magnet in Fig. 83A, which attracts its armature and releases the chime disc. At the same time the armature arm comes in contact with spring X, and closes the circuit of the battery which is connected to the magnet 30.

Its armature is attracted, and hammer 31, bearing against the centre pin of the lever 24, pushes the lever forward, causing the upper pin to slide along the sloping edge of 27 and drop into the notch, thus breaking the circuit of the chime-release magnet. Thus the chimes are released and the current cut off in less time than it takes to give one push on a bell-button.

One or two hints on obtaining the correct adjustments of the parts will be useful.

Grip the dial-board in the vice so that it stands fair and square. Let pin 26 rest on the highest point of the cam—the portion of the original circumference. Adjust block 29 so that the top pin of the lever 24 can drop from the notch with just a slight clearance; in other words, before the pin 26 has quite reached its full height.

Note also that lever 24 has sufficient inclination to cause it to fall away by gravity, and fit a temporary stop to prevent it falling farther than necessary. Then fix the position of the converted bell; the armature should be in contact with the cores when the pin is on the point of entering the notch. The position of contact 35 will be somewhat as shown, that is, nearly touching arm 23 when it is supported by lever 24.

A dial circle of more than 8 in. is not recommended, and it may with advantage be less, so as to keep the hands small and light. The hands can be cut from any thin metal, and the original brass fittings soldered to them. The lighter the hands and the smoother the works run, the lighter the gravity arm will need to be; and this means that less work will

be thrown on the pendulum—to the advantage of its timekeeping—and less work for the battery.

Pendulum.—A three-quarter-seconds pendulum is approximately 22 in. long from the underside of the

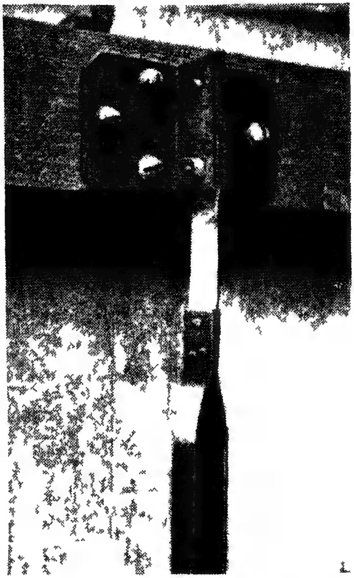


Fig. 88.—Suspension Bracket and Upper End of Pendulum Rod

suspension bracket to the centre of the bob, and as the present bob is 6 in. long, the length of the pendulum is 25 in. plus the adjusting screw and the brass plates at the top (see Figs. 89 and 90).

For the rod 40 there will be required a piece of straight-grained, well-seasoned hardwood, which

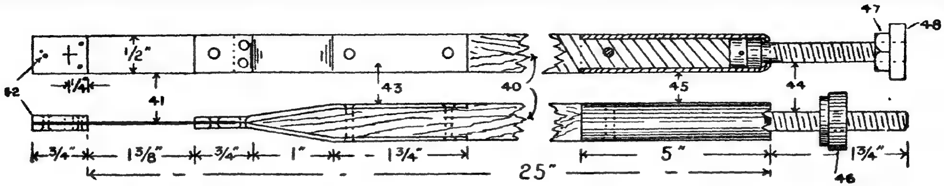
should afterwards be oiled or polished, about 2 ft. long and planed up to $\frac{1}{2}$ in. square.

The suspension spring 41 is a piece of thin, flexible steel $\frac{1}{2}$ in. wide specially rolled for the purpose (see photograph, Fig. 88). This can be obtained from dealers in clock materials. Ordinary clock spring is too thick; suitable spring can sometimes be obtained from corsets.

To one end of the spring are attached two stiffening plates of stout brass 42 by means of three tiny rivets, and a $\frac{1}{8}$-in. hole is bored through the lot to take a small screw-bolt. The lower edges of the plates should be exactly opposite one another and square with the edges of the spring. This is the most difficult part of the whole clock, so an alternative method of suspension will be given later. Now cut off the spring at about 2 in. from the plates, and rivet to it two strips of brass 43 $\frac{1}{2}$ in. wide, putting one rivet through it and two below it. Open out the brass strips, fit the wooden rod, and fix with two rivets; all these rivets are about $\frac{1}{8}$ in. thick.

To make holes through the steel strip, lay the strip on a piece of brass and punch with a fine-point centre-punch, so as to form a bulge on the other side. File off the bulge and ream out with the tang of a fine file: there is a danger of spoiling a reamer.

The regulating screw 44 (Figs. 89 and 90) may be about $\frac{3}{16}$ or $\frac{1}{4}$ in. in diameter, and the head securely fixed in a short length of brass tube 45 $\frac{1}{2}$ in. in external diameter. To fix it, file notches in the end of the tube, bend over the



Figs. 89 and 90.—Views of Pendulum Rod, Suspension Spring and Regulating Screw

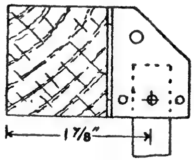


Fig. 91. — Alternative Method of Suspension

Fig. 92

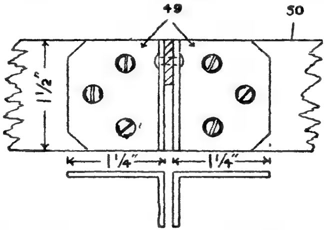


Fig. 93

Fig. 92.—Front View of Suspension Bracket

Fig. 93.—Plan of Metal Angle Pieces

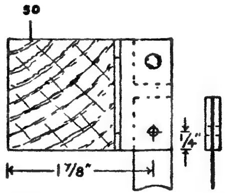


Fig. 94 Fig. 95

Fig. 94.—Side View of Suspension Bracket

Fig. 95.—Top of Suspension Spring

teeth (see Fig. 89), and sweat-solder into the joint. Bore a tiny hole in the tube just above the bolt-head to act as a vent hole when driving in the rod. Two nuts are required for the screw, a large one 46 (the regulating nut) to adjust the bob, and a smaller one 47 to lock the armature 48.

The armature is a piece of soft iron 2 in. long, $\frac{3}{4}$ in. wide, $\frac{3}{16}$ in. or $\frac{1}{4}$ in. thick, and tapped to fit the screw. Fig. 113 is a photograph of the regulating screw, armature and magnet.

The alternative method of suspension mentioned is shown by Fig. 91. The brackets project a little farther, and are fitted the thickness of the spring apart. Three holes are bored as shown; the centre one is for a plain pin which supports the pendulum, the two others are for two small bolts to pinch all tight.

The point to observe is that the lower edges of the brackets are *flush with one another and square with the face of the backboard.* A rivet near the top will add stiffness.

Note one point for future reference. The centre line of the pendulum is $1\frac{7}{8}$ in. from the backboard. (If $\frac{1}{8}$ in. more or less it does not matter, provided this is allowed for in the magnet, the contact board, and the trigger.)

Pendulum Bob.—The pendulum bob is of the same weight, and cast in exactly the same manner as the one for the one-seconds clock. An alternative method is to use a length of brass tube in place of the canister. Close one end with a disc, brazed in if possible. In

the centre of the disc fix a piece of brass tube, which will slide nicely on the rod, and pour in the metal in small quantities. One pouring will not unite with the previous one; as it is intended to keep the brass case on, however, it does not matter much, so long as there are no holes. Another method is to fill the case with small shot, but in this case the bob should be longer.

One of the simplest forms of suspension bracket is shown in Figs. 92 to 95 inclusive. It consists of two metal angle-pieces 49 (see Fig. 93) screwed to a stout piece of dry, hardwood 50, with a packing piece between them equal in thickness to the top of the suspension spring. A small bolt is passed through the three, and a nut put on to keep all firm—a very important point.

Trigger and its Support.—To carry the trigger a support shown by 50 (Figs. 96 and 97) is required. The one shown was built up from stout brass bent round a piece of iron, ½ in. square, and soldered. A nut 51 is soldered on one side to take a set-screw, and a steel pin about ⅛ in. thick is fixed in the opposite side, with a brass collar soldered on to add stiffness. It need hardly be said that the main body of this could be made from the solid.

The trigger 54 (Figs. 98 and 99) is a piece of knitting-needle or steel rod ⅛ in. thick, beaten out to ¼ in. at the bottom and hardened, and provided at the top with a hub so that it will swing freely but without shake on the pin 52 (see photograph, Fig. 100). To fix the steel and brass hub together

the hub of the alarm wheel can be used which in section is somewhat like Fig. 101. Drive the trigger end into the wheel hub, file a hollow (dotted lines) to take hub 53, solder together, and trim with a file. Note that the knife-edge is in line with the hub, and its centre $\frac{3}{4}$ in. from the centre of the pendulum rod.

Contact board.—Three views of the contact-board

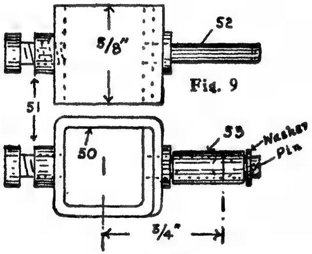


Fig. 97

Fig. 96.- Elevation of Fitting for Carrying Trigger

Fig. 97.—Plan of Fitting and Trigger

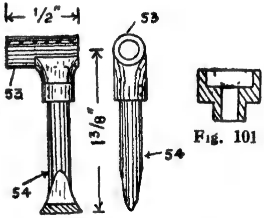


Fig. 98 Fig. 99

Figs. 98, 99, 101.—Details of Trigger

are given by Figs. 102, 103 and 104 (see also photograph, Fig. 105). It consists of a steel spring 57 supported horizontally, and with a small steel block soldered on its upper surface and a contact 58 on its lower side. Below this is an arm 59 carrying a contact screw 60. The adjustable support consists of two pieces of wood 55 and 56 glued together, and sliding between two guide strips 61 screwed to the backboard. A screw passes through the slot of the support and allows for adjustment.

The spring 57 may be a piece of clock spring ground thinner, a piece of corset spring, or a piece similar to the suspension spring. This is soldered to a bracket bent from a piece of brass cut to the pattern (Fig. 106).

Contact-block.—The little block 62 (Fig. 102) is a

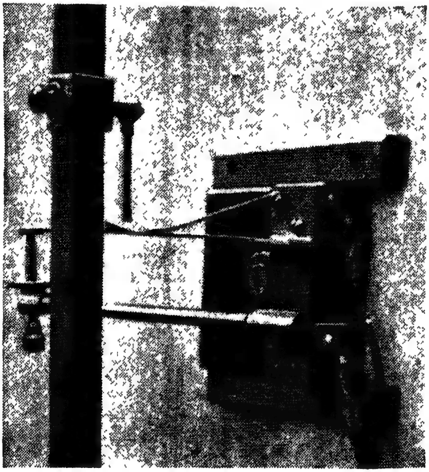


Fig. 100.—Trigger and Contact Board

piece of steel about $\frac{3}{8}$ in. long, $\frac{1}{4}$ in. high, and $\frac{3}{16}$ in. thick, with a tiny notch filed square across, as near the edge as possible and less than $\frac{1}{32}$ in. deep (An enlarged view is shown.) The spring must be very flexible, its centre line parallel with the backboard and $1\frac{1}{8}$ in. from it. A bent piece of wire 63 acts as a back stop, and also gives a tension to the spring if too flexible.

The arm 59 is a piece of stair rod to which is soldered the bracket 64 bent from a piece of brass cut to the pattern (Fig. 107). A brass knob is soldered on the other end and tapped to take a fine screw,

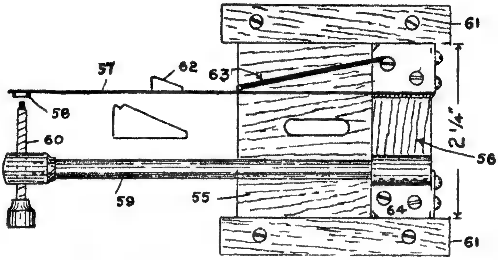


Fig. 102.—Elevation of Contact Board

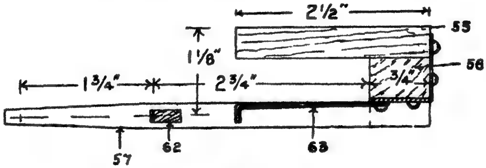


Fig. 103.—Plan of Contact Board

which, unless it works very stiffly, should be provided with a lock-nut.

The action of the trigger and the contact-board can now be traced. The trigger is carried by the pendulum, and the contact-board is screwed to the backboard. When the pendulum is at rest the trigger edge is about $\frac{1}{4}$ in. or so to the right of the notch in block 62 and about $\frac{1}{16}$ in. lower, so that as the

pendulum moves to the left, the trigger edge is trailed up the slope and then drops off the block.

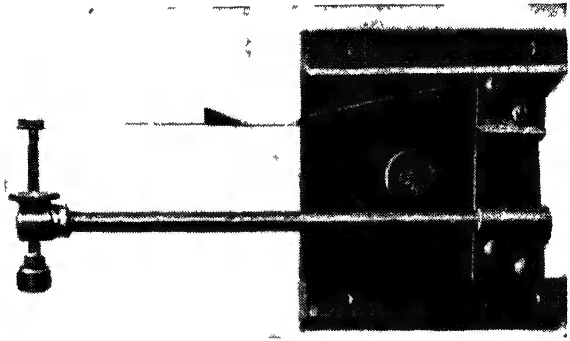


Fig. 105.—Contact Board

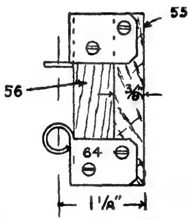


Fig. 104. — Elevation of Contact Board

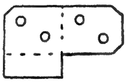


Fig. 106

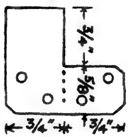


Fig. 107

Figs. 106 and 107 — Patterns for Brackets

This action continues at each swing to the left, until as the swing grows shorter the trigger fails to clear the block, and the edge drops into the notch. The exaggerated line diagram (Fig. 108) will perhaps

make this clear. The normal position of the trigger when at rest is shown at *a*, and *b* shows the trigger when it has failed to clear the notch. Now as the

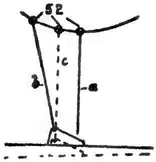


Fig. 108. – Diagram illustrating Action of Trigger

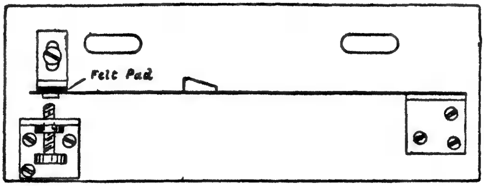


Fig. 109

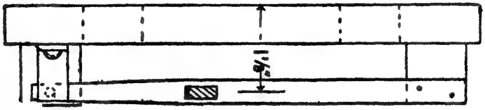


Fig. 110

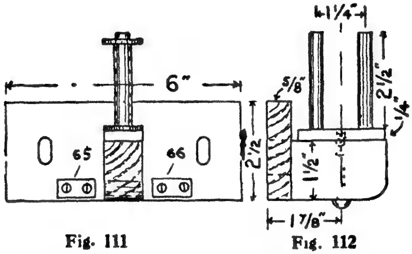
Figs. 109 and 110.—Elevation and Plan of Alternative Contact Board

pendulum returns to the right it presses down the block as shown in dotted lines *c*, causing the spring contact 58 to meet the contact screw 60, thus closing the battery circuit and energising the magnet, which gives the pendulum an impulse.

Another design for a contact-board is shown in

Figs. 109 and 110, and, after the description of the last, no details of these illustrations are necessary.

Electro-magnet and Bracket.—The electro-magnet and bracket are shown by Figs. 111, 112 and photograph, Fig. 113. The magnet cores may be of $\frac{5}{16}$-in. or $\frac{3}{8}$-in. round iron riveted into a yoke $2\frac{1}{4}$ in. long and $\frac{3}{4}$ in. or 1 in. wide. The bobbins should be $\frac{1}{8}$ in. short of the pole faces and $\frac{7}{8}$ in. or 1 in. in diameter, and



Figs. 111 and 112.—Front and Side Elevations of Electro-Magnet and Bracket

may be filled with No. 26 or No. 28 cotton-covered copper wire; about 5 oz. or 6 oz. of the wire will be required.

The bracket is built up as shown, the two pieces of wood being fixed together by a mortise-and-tenon joint and a screw. Slots are provided for adjustment and two plates of brass—or terminals—65 and 66 to take the wires.

Assembling the Parts.—Draw a centre line down the centre of the backboard. Fix the suspension bracket with stout screws from the back. Next fix the contact-board so that when the screw is in the

centre of the slot the little nick in the steel block is about $\frac{1}{4}$ in. to the left of the centre line. Set all square and fix guide strips. Hang the backboard on a wall and set it plumb. Hang the pendulum, and adjust the magnet bracket so that there is only about the thickness of a postcard between the armature and cores. The bracket should be very firmly fixed, or it will sooner or later be pulled up to the armature. The wiring is shown in dotted lines in Fig. 72, the ends being connected to two terminals. A hole can be bored through the bottom to admit the wires from the battery, whch consists of three Leclanché cells, 1-qt. size.

Adjusting the Pendulum.—Set the steel block 62 so that its notch is $\frac{1}{4}$ in. to the left of the trigger and about $\frac{1}{16}$ in. higher than its edge. Let the contact screw 60 be about $\frac{1}{16}$ in. below the spring contact. Pull the pendulum bob about 2 in. to one side and let go carefully. The trigger should ride backwards and forwards over the block for some time, and as it does so note if the spring 57 quivers at all; there should just be the faintest tremor; if not, the spring is too stiff or too much compressed by the back stop. When the trigger closes the contact, start counting the swings of the pendulum, and note how many it makes before the contact is again closed. Then try the effect of lowering the contact screw on the number of swings. Now try the effect of raising the trigger. In this way more will be learnt than pages of instruction will teach.

Roughly, it may be said that moving the contact-

board to the left increases the length of swing. Raising or lowering the trigger and contact screw alters the instant the contact takes place and the length of the contact. Contact should be made just when the armature is near the edge of the poles, and

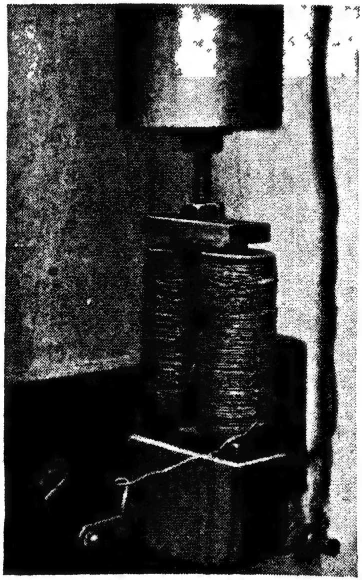


Fig. 113.—Regulating Screw, Armature and Magnet

broken again before the armature gets centrally over the poles; the best guide is counting the swings. With the pendulum running free, it should swing for one minute each impulse—eighty swings (or forty double ones, which are easier to count); when driving the works this will be reduced to about one-half. As the

battery deteriorates the swings per impulse will become less.

The best way to adjust the works—gravity arm and pawl—is to support them temporarily on the back-board so that the action can be watched. Failing this, shorten the length of the pendulum's swing until the gravity arm fails to move the ratchet, then gradually increase the swing again. See that the pawl acts properly before mounting the works in the case. If the chime release has been fitted it should be kept clear of the cam during these trials; one thing at a time is enough.

To Adjust the Chime Release.—Run the ratchet wheel slowly round until the pin drops off the arm of the cam, then put the hands on their spindles so that they both point to number 12.

A final word. The clock with chime release must not—cannot, in fact—be "put back"; the plain clock may, but it is better to always move the hands forward. Take every care not to damage or twist the suspension spring.

CHAPTER IV

Some Improvements to Electric Clocks

In the design of the two electric clocks described in the preceding chapters, simplicity and ease of construction, consistent with reliability, have been prominent features, and it will have been obvious to many readers who possess a better equipment of tools, including, perhaps, a lathe, that many of the parts would be better made specially for the purpose instead of using what was virtually scrap. As regards improved construction of details, several ideas will suggest themselves to the experienced metal-worker, therefore no mention is made of them, but suggestions are given for improvements in the more important parts. Included, also in this chapter, are a few alternative methods of small part construction. These will be dealt with first.

Detail Improvements.—Fig. 114 shows a small 30-tooth ratchet-wheel, made up of two 15-tooth alarm-clock escape wheels having teeth of the pattern shown. The space between the teeth is about twice the width of a tooth, so the boss is removed from one wheel and the hole made to fit the boss of the other, and the two soldered together. By arranging the spokes as close together as possible, a strong wheel can be made without soldering the rims, though the

rims can be soldered if care is taken to prevent the solder getting in the spaces between the teeth. The teeth shown on the right may be modified, if desired, by filing the back slightly, as shown on the left.

Any ordinary toothed wheel can be cut to a ratchet-wheel with a three-square file having a safe edge, by using the teeth as spacing guides, and cutting into the rim. If the rim is not deep enough, solder a disc of thin brass on the back. In large wheels two teeth

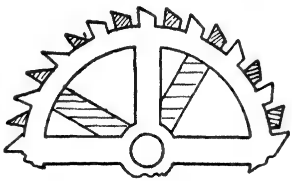
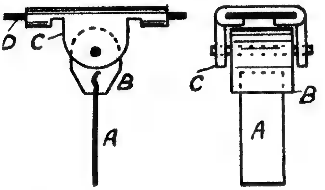


Fig. 114.—Making Ratchet Wheel of 30 Teeth

can be taken to form one ratchet tooth. Wheels of various sizes, having 40, 60, or 80 teeth, might be put aside to cut into ratchet-wheels of 20, 30, or 40 teeth. The first, in conjunction with a pair of wheels to reduce the speed of the seconds spindle to $\frac{1}{3}$, would do for a $\frac{1}{2}$-seconds pendulum.

A suggestion for making the clock more silent is shown in Figs. 115 to 120 inclusive. The trigger A is a piece of clock-spring fixed in a block of fibre B, supported by a carrier C which slides friction-tight on the contact spring D. A wide piece of thin copper foil might be fixed to the trigger to make it more "dead-beat." The carrier is cut from thin brass to the pattern (Fig. 117).

The steel block E (Fig. 118), which may be a square piece of steel, is supported by a fibre washer F having



Figs. 115 and 116.—Front and Side View of Trigger, etc.

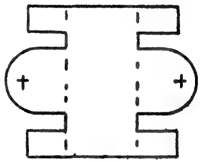


Fig. 117.—Pattern for Carrier

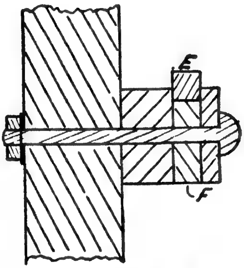


Fig. 118.—Vertical Section

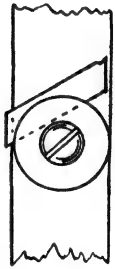


Fig. 119. - View of Steel Block

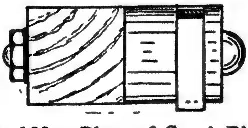


Fig. 120.—Plan of Steel Block

a part cut away to accommodate it and gripped between other washers. A fine screw-bolt through the pendulum rod and washers completes the arrangement. Fig. 119 shows a front view and Fig. 120 a

plan. With a round rod, the first washer would be filed hollow to fit the rod.

An Improved Magnet.—The following is a description of a magnet of a larger size and rather better finish than those previously described.

Fig. 121 shows the finished magnet. The two cores (Fig. 122) are cut from an old $\frac{3}{8}$-in. bolt, and are $2\frac{1}{4}$ in. over all. Three-quarters of an inch is turned down to $\frac{1}{4}$ in. on one end of each piece, $\frac{1}{2}$ in. being for the thickness of the yoke, and $\frac{1}{4}$ in. for riveting over. The yoke (Fig. 123) is $2\frac{1}{2}$ in. by $\frac{5}{8}$ in. by $\frac{1}{2}$ in., drilled out exactly $\frac{1}{4}$ in. and countersunk for riveting over the ends of the cores (riveted cold). Care must be used in riveting, and on no account must the end of the core be shattered. If this part of the work is not well done the magnet will be of little use. Riveting the cores into the yoke is a great deal better than using set-screws. The top of each core is drilled and tapped $\frac{3}{16}$ in.

Two pieces of soft iron (Fig. 124), $\frac{3}{4}$ in. by $\frac{3}{4}$ in. by $\frac{3}{16}$ in., drilled and countersunk $\frac{3}{16}$ in., are next required. These are fixed on the top of each core with $\frac{3}{16}$-in. set-screws, as shown by Fig. 125. Take care to well blacklead the threads of these set-screws, or they will not unscrew after they have been in the fire.

Now place the whole thing in a bright red fire, and leave it there until the fire has burnt right out; that is, leave over-night. This will take out any hardness in the iron. Take off all scale that has formed owing to the heat, and unscrew the top pieces. If

the screws are tight, warm over the fire or stove, and drop a little oil on them, allowing it to soak in; the screws will then come out quite easily. Clean up and

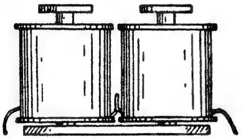


Fig. 121.—Magnet Complete

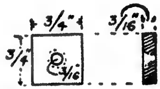


Fig. 124.—Soft-iron Top for Core

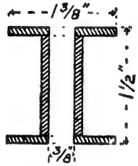


Fig. 126.—Bobbin

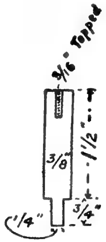


Fig. 122.—Core

Fig. 125.—Core with Top Screwed on

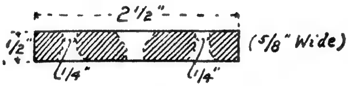


Fig. 123.—Yoke

give a coat of black enamel. This part of the job is now complete.

The bobbins (Fig. 126) are next taken in hand. These are made of tinplate, which is much better than brass tube. A milk-tin or any bright tinplate will be suitable. Make a tube about 3¼ in. long, a good sliding fit over the cores. Solder up the seam and cut in two.

Then cut out the flanges, four in all, $1\frac{3}{8}$ in. in diameter, with a $\frac{3}{8}$-in. hole in the centre. Solder these on to the tubes, and the bobbins are now ready for insulating with Empire cloth or notepaper well soaked in paraffin wax. Leave no tinplate showing where wire will touch.

Now wind the bobbins with No. 28 d.c.c. wire. Fill up the bobbins; with care 4 oz. of wire can be got on each. The wire can now be given a coat of shellac varnish, or may be dipped into hot paraffin wax.

Then fix the cores in the base of the clock, by means of a bolt or screw through the centre hole, taking care to leave room to slip on the back bobbin. Put on both bobbins, and connect in series. Now put the top pieces in position, and screw well home. Adjust the armature as near the pole-pieces as possible without touching, give the pendulum a swing to see that all is clear, and then connect the magnet up to the battery.

An Improved Pendulum.—Lightness and flexibility of the contact spring are essential, otherwise there is a slight tendency for the pendulum to swing on the twist, due to the reaction of the power required to lift the spring being imposed slightly away from the centre line of the pendulum. A pendulum, the design of which obviates this to a great extent, is shown in the accompanying illustration.

A (Figs. 127, 128, 129) shows a small piece of brass, the ends of which are bent at right angles and holes drilled in the ends to fit the pendulum rod.

This is soldered about 18 in. down from the top. B is another piece of brass soldered to the rod and also to the first piece A, so as to stiffen the pendulum after the rod has been cut to accommodate the trailer.

The trailer is suspended in a slot in a small piece

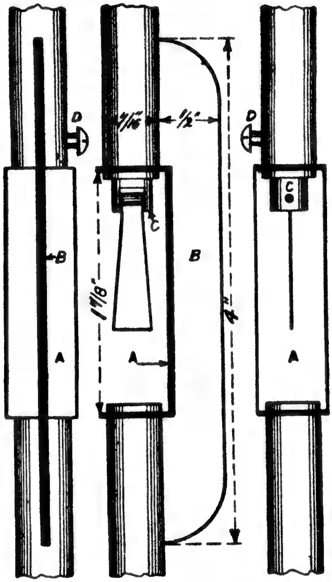


Fig. 127 Fig. 128 Fig. 129

Figs. 127, 128 and 129.—An Improved Pendulum

of brass C fitted inside the pendulum rod (which happened to be hollow), and held by a small set-screw D. This enables the trailer to be adjusted in a vertical plane.

The wood block supporting the contact blade was packed out, so as to bring the blade central under the

trailer in its new position. A trailer of this description can be fitted to a wooden rod by using two pieces of brass tube and fitting the rod into them.

Improved Wheelwork.—The main object in using alarm clocks, of course, is to bring the construction of electric clocks within the abilities of amateurs with few tools and no knowledge of clockmaking. That highly-finished works would be better goes without saying.

Almost any kind of clock works can be pressed into service, provided the wheels are light and all necessary parts in good condition. One advantage of the alarm clock is that they all, or nearly all, have a spindle which makes one revolution per minute, and hence it is easy to fit what may be termed a standard ratchet-wheel (30, 40 or 60 teeth) and a standard pendulum (1, $\frac{3}{4}$ or $\frac{1}{2}$ seconds).

With clocks in which the corresponding spindle does not revolve exactly once per minute, matters can be equalised by a variation in the number of teeth on the ratchet-wheel or in the length of the pendulum or of both.

It must be borne in mind that the electric-pendulum under consideration only moves the wheels every *double swing*, hence if the pendulum makes 90 vibrations per minute, the ratchet-wheel will only have half the number of teeth, namely, 45.

CHAPTER V

Cases for Electric Clocks

Two designs for cases for the clocks are shown in Figs. 130 and 134, and a photograph of a clock mounted in its case is shown in the frontispiece. One case is an ordinary hanging case and the other a grandfather clock standing case. The latter gives better facilities for the storage of the battery, thus making the whole clock self-contained; otherwise the selection of one style or the other is merely a matter of individual taste.

The dimensions given are suitable for the first clock described, but it will be a simple matter to modify these to suit the three-quarter-seconds clock.

A Hanging Case.—A photograph of this case, without the top and bottom mouldings, is shown in the frontispiece, and Fig. 130 shows a front elevation. The overall measurements are: 4 ft. 3 in. long, 10½ in. wide, and 6 in. deep, and the minute circle of the dial is 8 in. in diameter.

The backboard is 51 in. long, 9¼ in. wide, and 1 in. thick. It is essential that the back should be strong and rigid, and it is a convenience to be able to adjust the various parts on it clear of the rest of the case, so it is fixed in position by means of screws.

The sides are 51 in. long. 5¼ in. wide, and ⅝ in.

thick. The top and bottom are 1 in. narrower, to allow for the back fitting between the sides. The framework is dovetailed together as shown in Fig. 132, the top and bottom ends are both alike. A piece of wood A (Fig. 132), equal in thickness to the door, is fixed across the case at the top and bottom. This is shown again in the section (Fig. 133), where B is the backboard and C the bottom (or top). A moulding is planted round as shown.

The door is made the full length of the opening on account of the convenience of getting out the pendulum, and also because it allows a longer gravity arm to be fitted to the clock, if desired.

The small door which carries the works and the dial is fitted between the sides and flush with their face; or, better still, the thickness of the dial below their face. This door, it will be noticed, is hinged on the right, so that the door can be opened or closed while the pendulum is in motion. The door should only be closed while the pendulum is on the journey to the right. The face of the door is of $\frac{3}{16}$-in. three-ply, and behind this is glued $\frac{1}{2}$-in. stuff mitred as shown in Fig. 131, so as to leave an opening large enough to take the works.

The front frame of the works fits up to the three-ply, so that it is necessary to cut an opening in the three-ply to accommodate the wheels on the front frame. A stop D (Fig. 131) is fitted on the inside of the door to arrest the gravity arm when it has returned to the centre line of the clock. This stop may be made as Fig. 66, a piece of brass carrying a piece of

felt and having a slot instead of two holes, so that it can be adjusted. It will be necessary to mount it on a block of wood.

The suspension cock is fixed close up to the top of

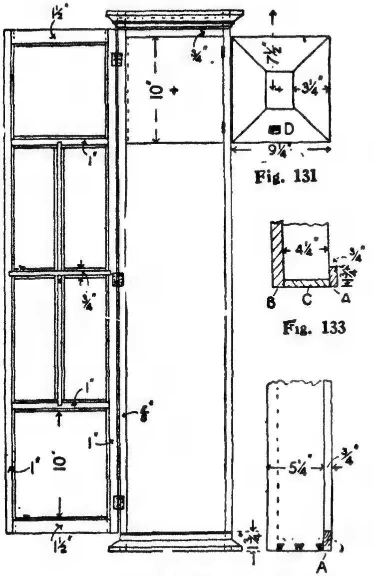


Fig. 130 Fig. 132

Fig. 130.—Front Elevation of Hanging Case

Fig. 131.—Back Elevation of Inner Door

Fig. 132.—Lower End of Case

Fig. 133. — Section of Lower End of Case

the case, so as to take advantage of the inch gained by forming the cornice in the manner described.

The various parts can be mounted on the backboard as shown in the photographs, and got into working order with the backboard, apart from the case.

A stout hanger should be let into the backboard at the top, and a smaller plate at the bottom, the latter

being to prevent the clock from being pushed out of plumb.

Case for Grandfather Clock.—The construction of this case has been kept as simple as possible. Owing to the larger dial it is possible to have two doors and a built-up cornice. After what has been said in regard to the hanging case, it will not be necessary to say much about this, so only a few details of the construction will be given.

The total height of the case is 73 in., and the dial is 10 in. in diameter. The backboard is 66 in. long, 11½ in. wide, and 1 in. thick; and to prevent warping, three or four battens, about the thickness of the skirting board of the room, may be screwed across the back.

The sides A (Figs. 134 and 135) are 53½ in. long, 6½ in. wide, and ¾ in. thick; and the top B, which is 1 in. narrower to allow the backboard to fit between the sides, is lap-dovetailed into the sides.

In the lower portion the sides C are 18½ in. long, 8½ in. wide, and ¾ in. thick. To get the necessary projection, pieces of wood D, 3 in. wide, are screwed on the inside as shown, and pieces P inserted as filling between the backboard and sides. The side A is screwed to D, and a bottom E is fitted about 4 in. from the ground.

Across the front of the case and resting on the narrow sides A is fitted a piece of wood F, equal to the thickness of the door, and on the front of this piece is fitted another piece G, 1 in. thick, to give the necessary projection at the front. Over all is fitted the piece J.

Instead of making this front solid, it may be framed up and fitted with a loose panel, and the

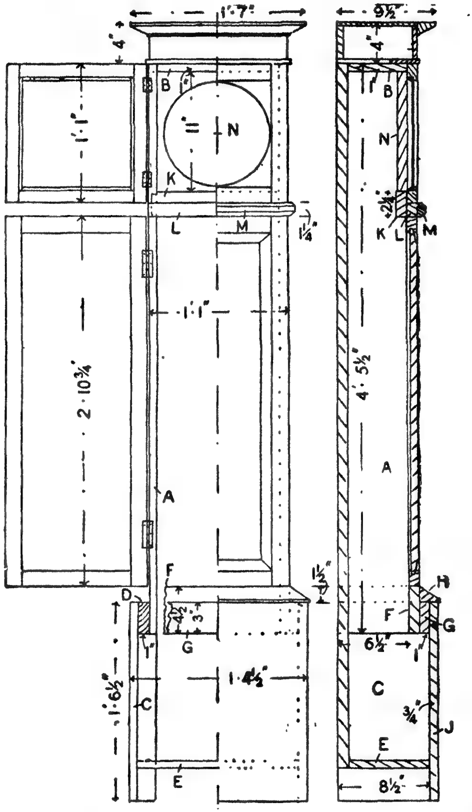


Fig. 134.—Composite Front Elevation of Grandfather Case

Fig. 135.—Sectional Elevation

batteries kept in this lower part of the case, when the loose panel will be found a convenience. A moulding H completes this lower case.

The stretcher piece K is dovetail-housed into the sides; a piece L, 1¼ in. wide and the thickness of the doors, is fitted on top of this, and a moulding M planted on the front and sides. The inner door N is 11 in. high and 11½ in. wide, and built up and hinged as in the other case.

A cornice can be built up after the style of a wardrobe cornice.

The big door is shown with a raised panel; but can be fitted with glass if desired. In this case the backboard might be made of prime canary wood, and faced with ¼-in three-ply mahogany or oak, or of the same wood as used for the case.

As mentioned in regard to the hanging case, it is a convenience to be able to remove the backboard, so it is suggested that it be fixed with screws.

CHAPTER VI

Electric-Impulse Clocks

As most readers are no doubt aware, electric-impulse clocks are so called because they are driven by electric impulses transmitted at prearranged intervals, say minute or half minute, by a controlling mechanism variously known as a master clock, controller, transmitter, or time-switch.

The master clock may be an ordinary spring-driven or weight-driven clock fitted with a device for closing an electric current at the desired intervals, but more generally an electrically-driven pendulum is used for the purpose.

The pendulum employed for the transmitter about to be described is similar to that used for the three-quarter-seconds electric clock. A pendulum beating seconds or half-seconds will serve equally well, as will be explained later.

It is necessary to mention that the various pieces of mechanism about to be described were designed with a view to bringing their construction within the abilities of any patient amateur with a modest equipment of tools and a good "scrap" box: the only machine tool used is a small drilling machine. The necessity for turning is avoided by using spindles taken

from old clocks. Holes for bearings can be carefully reamed out with "broaches" or reamers.

Although the mechanism may be rugged in appearance, the actual rubbing surfaces are as carefully finished as in a well-made clock. Various parts of

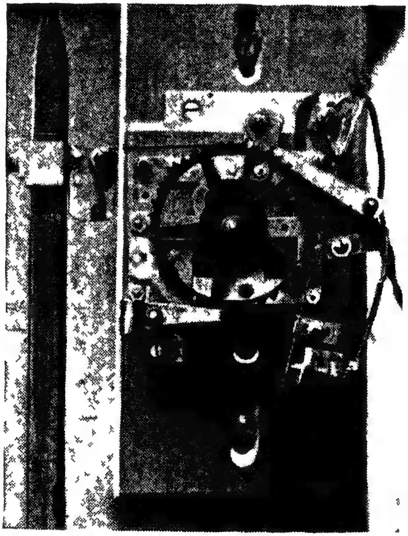


Fig. 136.—Transmitter in Position

the clock, etc., might be made much smaller and arranged more compactly, though this demands rather more skill in the making: the skilled worker has plenty of scope for effecting improvements.

Assuming that no one will implicitly follow the drawings, the few measurements given are intended to be a rough guide, the working drawings, however, are to scale.

The Transmitter

The transmitter part of the system is shown in Figs. 136 and 137. Attached to the pendulum 1 is a hook 2 which pulls round the count wheel 3 a

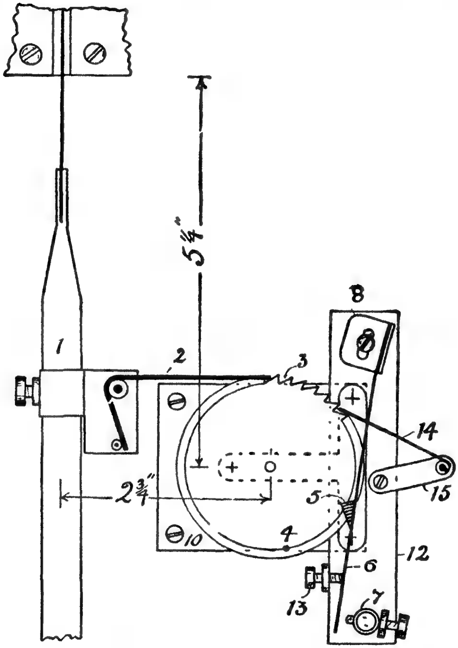


Fig. 137.—Front View of Transmitter and Pendulum Fitting (Incomplete)

distance of one tooth each time the pendulum swings to the left. A steel block 5 attached to spring 6 is set in the path of pin 4, which, in passing, pushes back the spring and closes the circuit at terminal 7, thus sending an impulse to all the clocks in the series.

It will be seen that the count wheel 3 can be modified either as regards the number of its teeth or the number of its pins, to send impulses at half-minute or minute intervals and to work with a 1 seconds, $\frac{3}{4}$ seconds, or $\frac{1}{2}$ seconds pendulum.

Remembering that the wheel turns one tooth for each double swing—right to left to right—a wheel to send one minute impulses would require for 1, $\frac{3}{4}$ or $\frac{1}{2}$ seconds pendulum 30, 40 and 60 teeth respectively and have one pin. With another pin set diametrically opposite, the same wheel would send $\frac{1}{2}$ minute impulses, or again, a wheel with one pin and half the number of teeth given above would send $\frac{1}{2}$ minute impulses.

If the teeth are large the pin 4 has a long traverse, and hence it is easy to adjust the contact; if the teeth are small the contact may be closed in two stages, the pin pushing the spring back part way and then waiting for the next movement of the wheel to complete the closure and clear the block.

The front elevation (Fig. 137) shows the essential parts of the transmitter; the photographs (Figs. 136 and 138) show in addition an alternative arrangement of the pawl or backstop and also a friction spring 9—sec Fig. 141. This latter consists of a brass arm to which is soldered a length of watch spring which bears lightly on a brass collar fixed on the arbor of the count wheel. The arm is riveted to the back frame so that it works stiffly, and a slot and screw are provided so that the pressure on the collar can be adjusted.

This spring will probably not be necessary unless the wheel is badly balanced or exhibits a tendency to continue its forward motion after the fork has pulled it the proper distance.

Count-wheel.—This wheel, which has 40 teeth, is

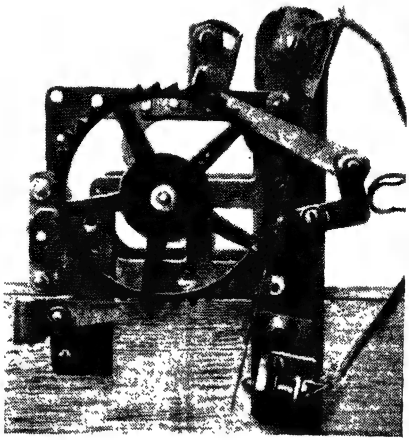


Fig. 138.—Transmitter Removed from Support

made from a clock wheel of 80 teeth, and is nearly $2\frac{1}{2}$ in. in diameter. The teeth are marked out, using the original teeth as guides, and then filed with a three-square file.

In Fig. 139 two forms of teeth are shown; those in the upper portion with radial faces are easier to set out, but the shape of the bottom four is preferable. (Readers used to woodworking saws will recognise the

latter as the shape of half-rip saw teeth.) The wheel can be cut from sheet brass, but as much surplus metal as possible should be cut away to make the wheel light. A pin 4, say a piece of gramophone needle, is fitted in the position shown, and if $\frac{1}{2}$-second impulses are desired, a second pin should be fitted diametrically opposite *equidistant* from the centre.

If the wheel be made with 40 teeth it can be quite

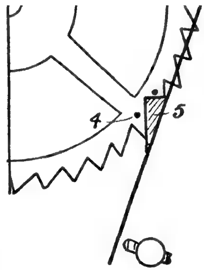


Fig. 139.—Part of Count-wheel

easily altered to send half-minute impulses if necessary by simply adding the second pin. If $\frac{1}{2}$-minute impulses only had been required the wheel would have been smaller and have had 20 teeth and 1 pin.

Framework.—The count-wheel may be mounted on the centre spindle of an alarm clock, all the surplus parts of the front frame being cut away, but a frame built up as shown in Fig. 140 will look much neater. The base plate 10 is $2\frac{3}{4}$ in. long and $2\frac{1}{4}$ in. wide with three pillars, taken from an old clock, riveted to it—the central pillar is shown pulled away in Fig. 140. A T-shaped piece takes the place of the front frame.

In Figs. 137 and 141 the positions of the pillars are shown by crosses.

Contacts.—Screwed to the underside of the front frame is a strip of wood or fibre 12 (Fig. 137) 4½ in. long, ⅞ in. wide and ⅜ in. thick. On this is fitted the contact spring built up as shown in Fig. 143: a piece

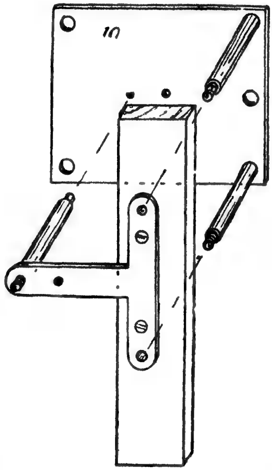


Fig. 140.—Frame for Transmitter

of watch spring, with a steel block 5 soldered on one face and a strip of silver 11 on the other, is soldered to an adjustable foot 8. An enlarged plan of the steel block is shown in Fig. 144, the shape being that of a 60° triangle. A contact screw 7 is fitted near the lower end of the insulating strip and an adjusting screw 13 at the side.

Pawl.—The pawl 14 may be built up as shown in Figs. 145 to 148. It consists of a strip of thin brass

fitted with a hub which works freely on a stud. The end of the brass strip may be turned up as shown—this form is very useful in preventing backlash when teeth with radial faces are used—or a pin may be

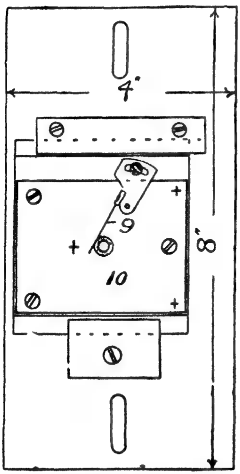


Fig. 141

Fig. 141.—Adjustable Support for Transmitter

Fig. 142.—Side of Support with Frame and Countwheel in Position

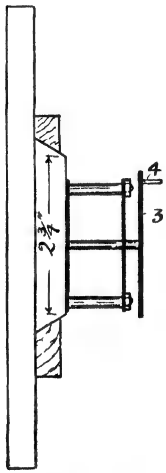


Fig. 142

substituted. The hook 2 (Fig. 150) suggests the method of making the pawl shown in Fig. 137.

Pendulum Fitting.—A simple method of building up this part is shown in Figs. 149, 150 and 151. A strip of brass, cut to the pattern (Fig. 151), is bent round a suitable piece of square rod, riveted together as shown, and a boss, which is afterwards tapped for a $\frac{3}{16}$-in. set-screw, soldered on one side.

The hook may be made from the stem of a lady's

hatpin, which after being softened and polished is bent to shape and soldered to a suitable hub, the hook end being then rehardened. The alarm wheel of a clock will provide a suitable hub and a piece of the spindle will do for the stud. A pin covered with fine

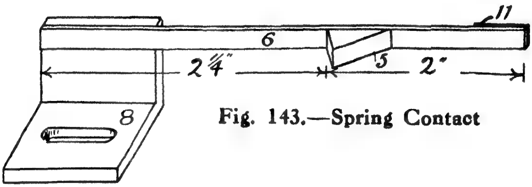


Fig. 143.—Spring Contact

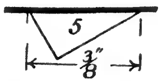


Fig. 144. — Enlarged Detail of Block 5

Fig. 145

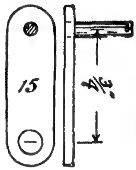


Fig. 146

Figs. 145 and 146.—Adjustable Support for Pawl

rubber tubing is fixed for the tail end of the hook to rest against.

An alternative method of making the fitting is shown in Figs. 152 and 153. A strip of brass $\frac{5}{8}$ in. wide is bent round an iron rod—round or square, according to the section of the pendulum rod—and made to embrace a piece of brass 16 about 1 in. long and $\frac{5}{16}$ in. wide and as thin as can be drilled comfortably to take the rivets

The gathering hook may be a piece of brass wire—bird-cage wire—with the tail end fitted to a small brass block (Fig. 154) bored out to fit a thin clock-wheel spindle. The tail of the hook can be bent as shown and the other end bent to form a loop into which a piece of very thin round glass rod can be cemented to form the gathering pallet.

Fig. 147.—Pawl, Front View

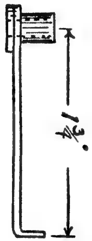


Fig. 148.—Pawl, Side View

The little block (Fig. 154) is a good all-round fitting for pawls, etc., so a few might be prepared—or partially prepared—beforehand. A bar of brass about $\frac{5}{16}$ in. or $\frac{3}{8}$ in. wide and about $\frac{3}{32}$ in. thick can have a number of $\frac{1}{16}$-in. holes bored through edgewise about $\frac{3}{8}$ in. apart. The end can be shaped and the block sawn off, leaving other details of finish until required for use—a hole in the end for a pawl like 14 and a slit for one like Figs. 147 and 148. Another bearing, which does not require the use of a drilling machine, is bent from thin sheet brass as in Fig. 155.

Mounting the Works.—When the count-wheel is in position it will be about $\frac{1}{8}$ in. or $\frac{3}{16}$ in. in front of the gathering arm, so there will be a space of about 1 in. between the back plate and the back board of the clock. Advantage is taken of this space to introduce the double adjustment shown in Figs. 141 and 142.

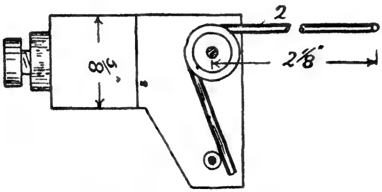


Fig. 149.—Elevation of Pendulum Fitting

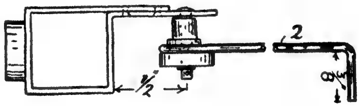


Fig. 150.—Plan of Pendulum Fitting

The block carrying the works slides between guides, and is secured in the correct position by tightening up the lower guide.

Assembling and Adjusting the Parts.—The two measurements given in Fig. 137 locate the mechanism if the frame of an alarm clock is used; but by adopting the simplified frame shown, it will be possible to set the wheel somewhat nearer the pendulum and use a shorter gathering arm.

Having fixed the parts as shown in Fig. 137, that

is, with the gathering pallet resting on the back of the highest tooth, adjust the pendulum so that it has a swing of about 2 in.—1 in. on each side of the centre line; the gathering arm can be slipped up out of action in the meantime.

Now, starting from the position (Fig. 137) with the pendulum moving to the right, the pallet will slide up the back of the tooth, drop over the point to a slight extent, and then describe an upward curve. On the return swing it will engage the tooth near the point and pull the wheel round a little way.

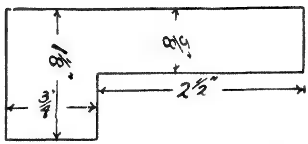


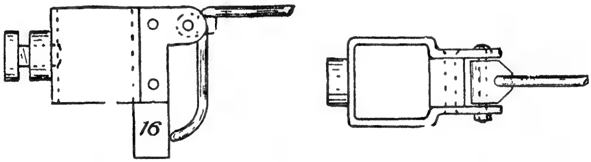
Fig. 151.—Pattern for Collar on Pendulum

As the pendulum starts its journey to the right the pallet will drop, slide up the back of the tooth, and repeat the process before mentioned. If the action is not as described a little thought will show what adjustments are necessary. The arm of the pawl 14, which need only be friction tight during the trial, may now be firmly fixed.

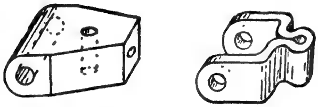
The contact spring can now be adjusted, and in Fig. 139, which shows one-quarter of the count-wheel, the position of pin 4 is shown in two positions—before and after contact. Here, again, a little experimenting will be of more help than a lot of instruction.

In tightening the screws fixing such things as arm

15 and foot 8, there is always a tendency for the screw to seize and carry round the part being fastened, even when using a washer under the screw-head. In such cases the use of an anchor-washer something like Fig. 156 is suggested—an example of such a washer and the method of using it may be seen under one



Figs. 152 and 153.—Alternative Pendulum Fitting



Figs. 154 and 155.—Alternative Forms of Hubs for Pawls

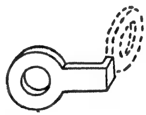


Fig. 156.—Special Form of Washer

of the balance screws of a drum-clock. The dotted portion of Fig. 156 might be added to the washer of foot 8—the hole being tapped and provided with a screw—to form a terminal.

Three Impulse Clocks

Having completed the description of the transmitter it is proposed to describe three impulse clocks. No. 1 suitable for 1-minute impulses and small hands, No. 2

suitable for ½- or 1-minute impulses with larger hands, and No. 3 suitable for ½-minute impulses without the use of a 120-toothed wheel.

As all the clocks have certain parts in common (pawls, magnets, driving arm, etc.), variations have been made in these parts to serve as alternative methods of construction.

Before commencing it will be necessary to decide whether to employ minute or half-minute impulses. A half-minute clock, of course, gives a more nearly correct indication of the time, but in most household clocks an error of one minute is not of much consequence. Although the half-minute clock takes twice the number of impulses to drive it, it does not necessarily use twice as much current in a given time.

Generally speaking, the teeth (120) of the half-minute count-wheel will be much smaller than those of the minute wheel (60); consequently the armature of the magnet moves a shorter distance from the poles, and therefore works with less current.

It is perhaps hardly necessary to mention that all the clocks in the series should be as near alike in general construction as possible, so that current need not be wasted unnecessarily owing to one clock being more sluggish than the others; the duration of the contact (regulated by the screw of the transmitter) will depend on the action of the most sluggish clock.

It is suggested, too, that the dials, and hence the hands, should not be larger than is absolutely necessary. Long and comparatively heavy hands, especially

the minute hands, have a tendency to drop of their own accord when travelling downhill.

The bobbin of each magnet has a resistance of 3 ohms. Those of clocks Nos. 1 and 2 are $1\frac{1}{2}$ in. long and 1 in. in diameter, and are each wound with eleven layers of No. 26 cotton-covered wire. The

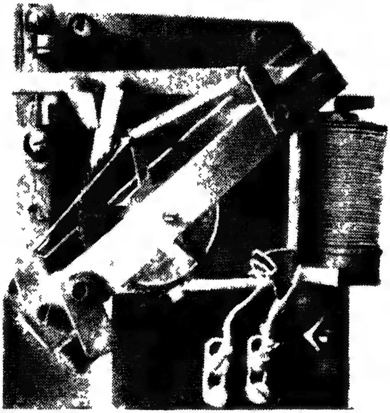


Fig. 157.—Photograph showing Works of One-minute Impulse Clock

magnet of clock No. 3 is slightly smaller, and a suitable magnet for this could be obtained from an electric bell.

Apart from the ratchet wheel, the only other wheels required are those on the front of the frame, the 12 to 1 gear, and these can be taken from an alarm or similar small clock.

One-minute Impulse Clock.—A view of the works is shown in the photograph (Fig. 157). (Two of the

back-stop pawls shown are unnecessary, but are given as alternative suggestions.)

By reference to Fig. 158 the action of the works can be traced. When magnet 1 receives an impulse it lifts arm 2 to the position shown, causing the driving pawl 3 to step up one tooth of ratchet wheel 4. It is during the brief interval the arm is thus held up that a heavy hand has an opportunity of falling forward and carrying the ratchet wheel round with it; it cannot fall backwards on account of the retaining pawl 5. When the pull of the magnet ceases, arm 2 drops and the wheel is pushed round a distance of one tooth, when the end of the arm comes in contact with the lower stop. At the same instant pawl 3 will be in contact with the fixed stop 6 thus locking the wheel until the next impulse is received.

Frame.—This consists of two strips of brass $\frac{1}{2}$ in. wide and about $\frac{1}{16}$ in. thick, $4\frac{1}{2}$ in. and 5 in. long respectively, braced together by two pillars taken from an alarm clock, that is, about $\frac{7}{8}$ in. apart.

The brass strips should be made a little longer at first, and after being made flat and polished they should be riveted together near the ends and their edges filed. The positions of the various holes can be set out according to the dimensions in Fig. 160, and small pilot holes bored through both plates, after which the rivets may be removed. Before taking the plates apart a little notch might be filed on one edge and a centre-pop mark made on the outer faces, so as to make sure that the plates are afterwards put together in the same relative positions.

The making of small pilot holes was mentioned because the companion holes in back and front plate will, with one exception, most probably be of different diameters.

After the pillars have been fitted, the holes for

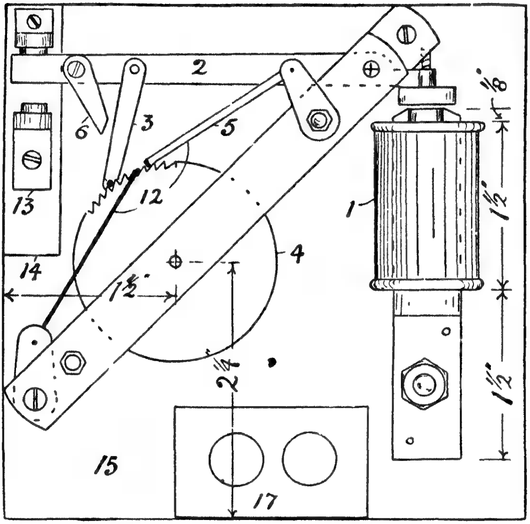


Fig. 158.—Back Elevation of Works of One-minute Impulse Clock

the centre spindle 7 can be carefully reamed out to size; after this is fitted the position of stud 8 can be marked out by using the old clock frame—from which stud 8 has been removed—as a template. The two pivot screws 9 and the axle between them supported the balance wheel of the drum clock; if any difficulty is experienced in adapting this bearing an

ordinary pivot bearing may be substituted. It is quite possible to fit (or squeeze) many of these pivot screws into holes tapped $\frac{1}{8}$-in. Whitworth. On a pinch they will serve as their own tap.

Ratchet Wheel.—This is $1\frac{3}{4}$ in. in diameter and has 60 teeth. It is mounted friction tight on the spindle 7 just inside the back plate, as shown in Fig. 160. The relative positions of arm 2, pawls 3 and 5, and stop 6 can be gathered from this view.

Weight Arm.—This is made of thin stiff brass 4 in. long, $\frac{3}{16}$ in. or $\frac{1}{4}$ in. wide at the narrow end, and $\frac{3}{8}$ in. wide at the rear end. Any surplus length can be cut off later; 2 (Fig. 160) shows this. A portion at the rear end is reduced to half width and bent into a loop to take a fine brass screw 10, as shown in Figs. 161 and 162.

To obtain a pointed pivot the rim and arms can be cut from the balance wheel of the clock, leaving the hub firmly fixed for arm 2 to butt against; the collar which held the hairspring is pushed up against the other side of the arm and the lot soldered together.

Armature.—Part 11 (Figs. 161 and 162) is about $\frac{7}{8}$ in. long, $\frac{1}{2}$ in. wide, and $\frac{3}{16}$ in. thick. In the centre is a hole to take screw 10. Solder is sweated in to make all secure. The main object of screw 10 is to afford a convenient means of adding a counterweight (if necessary). Should the arm and fittings 3 and 6 prove much too heavy, the arm may be lightened by boring holes along it or counteracted by a nut or two on screw 10.

Driving Pawl.—Part 3 is built up as shown in

Figs. 163 and 164; a piece of gramophone needle is used for the pin. Its position on the arm will be about 2¼ in. from the pivot, but this, and the exact position of the pin, had better be found by trial.

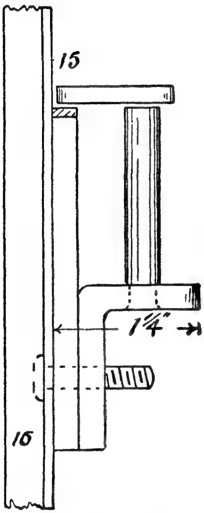


Fig. 159. — Side View of Magnet, Back Plate and Dial-board

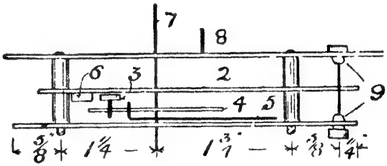
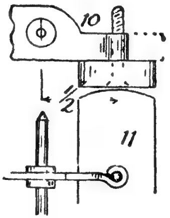


Fig. 160.—Plan of Frame



Figs. 161 and 162.—Rear End of Driving-arm

The pin engages the ratchet wheel about seven teeth down, and when at the end of its stroke it has an inclination of about ¼ in. from the vertical. The object of this inclination is, of course, to ensure the pawl swinging to the right to engage the next tooth when the arm is raised.

Stop.—The exact angle of the end of the stop 6 (Fig. 158) can be found by trial; but approximately it should be of about the shape shown.

Backstop Pawls.—These are built up in a similar manner to that of the transmitter; alternative patterns and methods of fixing are shown in Fig. 158.

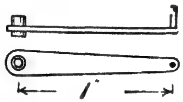
Buffer Stop.—There are two buffer stops (Fig. 158). They are made from thin sheet brass cut to the pattern (Fig. 165), the thin arm being bent round to embrace a leather, felt or rubber plug. They are supported at the correct distance from the back by a strip of wood 14 screwed to the back plate 15.

Back Plate.—Either stout brass or sheet iron is suitable for this; the size is $4\frac{1}{2}$ in. by $4\frac{1}{2}$ in. The measurements on Fig. 158 give the position of the centre spindle, and the plates are set at angle of 45°.

An opening must be cut through the plate to accommodate the motion wheels on the front of the frame. To form this opening, circles are scribed a little larger than the wheels, and a number of holes are bored around the circumference close together. The waste metal can be broken away, and the edges trimmed with a file. The position of the hole for the pivot screw 9 (and any others) should be marked before cutting any metal away. The frame is fixed to the back plate by two small screws.

Although the description has been left until now, the back plate should have been completed so far before fitting arm 2.

Magnet.—The magnet is shown in Figs. 158 and 159, and is built up from strip iron $\frac{5}{8}$ in. wide and $\frac{3}{16}$ in. thick, and a round piece $\frac{5}{16}$ in. in diameter to form the core. It will be observed that it is the single bobbin type. The core is riveted to the right-angled piece, which is then riveted to the straight strip. A short slot is cut to accommodate a $\frac{3}{16}$-in. bolt. This bolt fits tight in the back plate, and is further secured



Figs. 163 and 164.—Driving Pawl

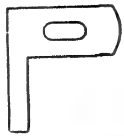


Fig. 165.—Pattern for Buffer Stop

by soldering. The back plate is fixed on a piece of wood 16 of suitable size to carry the dial.

A block of wood 17 about $\frac{1}{2}$ in. thick is fixed where shown to take two terminals—indicated by circles—which, of course, must be insulated from the back plate. The type of terminal recommended is that often met with in telephone work; they consist of a strip of stout brass with countersunk holes for fixing screws, and two screws with slotted heads for fixing the wires.

General Remarks.—In order to avoid unnecessary friction where two surfaces rub together, as, for instance, pawl 3 and arm 2, the end of the bush

should be rounded off as in Figs. 166 and 167, so as to leave a rubbing surface of small diameter. The shoulders of wheel arbors are often rounded off in this manner.

Where wheels (and pawls) run on studs—the wheel running on stud 8, for instance—they are often retained by a washer and pin. In the case of pawls, a split collar like Figs. 168 and 169 is preferable. The

Figs. 166 and 167.—Rounding of Ends of Bushes

Figs. 168 and 169.—Elevation and Plan of Split Collar

spindle of the wheel can be used for the stud, and the bush can be filed down and slit to form the collar.

As the frame suggested is of thicker material than that of alarm clocks, care must be used when removing the pillars and stud 8 from the old frames to leave the reduced portion as long as possible to allow for re-riveting; the pillars may be knocked out of the frame and the burr filed off at the sides. It may be necessary to employ countersunk holes in the new frame.

Stud 8 may be let into the frame a little way and

the pinion which runs on it shortened somewhat if necessary. When riveting this stud, a pin should be fitted into the pin-hole, or there is a danger of the stud being distorted at this point.

After the suspension screws 9 have been adjusted they should not be unscrewed; it is better to remove

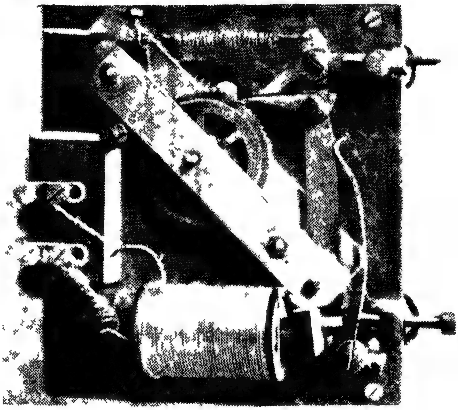


Fig. 170.—Half- or One-minute Impulse Clock Complete

the nuts from the pillars when it is necessary to take out arm 2.

Half- or One-minute Impulse Clock.—This clock is shown in the photograph (Fig. 170), a back elevation being shown in Fig. 171.

Frame.—This consists of two plates provided with pillars taken from a drum clock. The back plate is $3\frac{1}{2}$ in. long and $\frac{1}{2}$ in. wide; the front plate is $4\frac{1}{4}$ in. long and $\frac{3}{4}$ in. wide. The pillars, etc., are arranged

along the centre line of each, and spaced according to the measurements in Fig. 171. A portion of the lower end of the plates is filed off to clear the armature. The motion wheels are arranged as in clock No. 1, and holes cut out of the base plate to accommodate them. The base plate is 4 in. square, the central spindle is placed $\frac{1}{4}$ in. above the centre, and the frame (fixed by two screws) is set at an angle of 45°.

Ratchet Wheel.—This is about $1\frac{1}{2}$ in. in diameter, and the 60-tooth spaces are right-angled, being cut with a square-cornered file instead of 60° as before. (It is possible to make this out of the centre wheel of a drum clock, the teeth of which, usually 54, should first be filed off.)

Driving Arm.—Part 2 (Fig. 171) is very similar to the one previously described. The lower end is filed away to receive the armature, which is then riveted and soldered on. Practically the only difference is in the driving pawl 3, which is shown again in Figs. 174 and 175. It is of iron or steel $\frac{1}{4}$ in. wide, $\frac{1}{8}$ in. thick, and fitted with a hub $\frac{1}{4}$ in. long. It works on a stud made from the arbor of a clock wheel, the hub of the wheel being retained and soldered to the back of the arm, and is kept on by a split collar. Driving arm, armature, etc., are shown in Fig. 173.

The exact position for fixing the pawl is better found by trial. As a guide it may be said that the pawl when horizontal engages the wheel at a point about 45° above the horizontal. In Fig. 171 it has just dropped to gather a tooth, and the back of the tooth from which it has dropped is horizontal; the

point of the tooth had better be a little below rather than above the horizontal.

A small block of brass is soldered to the arm to bring stop 4 directly over the pawl. After the pawl has been adjusted, a small hole can be bored through the stop and arm to take a steady pin.

Driving Springs.—Alternative forms are shown in

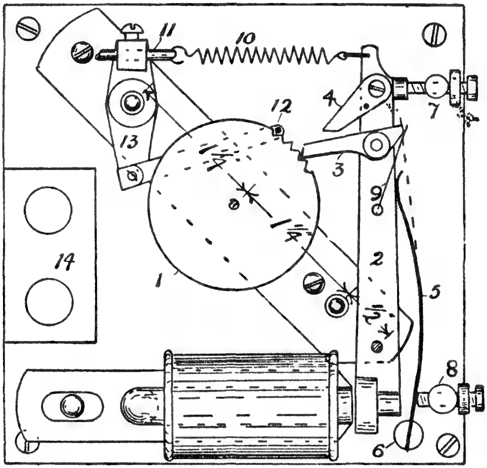


Fig. 171.—Back Elevation with Back Plate Removed

Fig. 171. The flat spring 5 is made from a piece of clock spring $\frac{3}{16}$ in. wide, and should be very flexible. It is supported by a pillar 6; the contact pillar of an electric bell will serve. Another pillar 8, provided with a screw and lock-nut, will serve to adjust the pressure of the spring, which should not be more than is absolutely necessary to drive the clock.

An alternative method of employing this spring

is suggested by the broken line; the spring bears on the end of the pawl. Used in this manner the spring first presses the point of the pawl downwards, to engage a tooth, and then pushes it sidewise to drive the wheel. Care must be taken that the downward

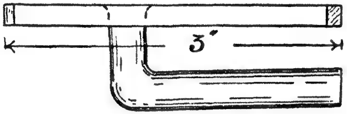
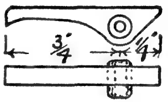


Fig. 172—Plan of Magnet Cores



Figs. 174 and 175.—Driving Pawl

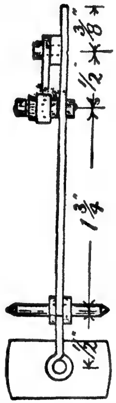


Fig. 173.—Side Elevation of Driving Arm

pressure is not more than necessary to ensure the pawl dropping one tooth.

Another method of causing the pawl to drop is by means of a single strand of brass or steel wire or a piece of watch spring F, attached to a stud projecting from the side of the arm; a somewhat similar device is often met with in clockworks. The other spring 10 is about 1 in. long, and was made from very thin brass wire by coiling it round a knitting-needle. The rod

11—an alarm wheel spindle—which passes through a metal block provided with a set-screw, is used for adjusting the tension of the spring; the arm carrying the block is clamped to the upper pillar, and may be similar to, or a continuation of, arm 13 (Fig. 176).

Backstop Pawl.—This is built up as shown in Fig. 176, part 12. Arm 13 is soldered to a collar provided with a set-screw for clamping it to the pillar.

Electro-magnet.—This is constructed as shown in Figs. 171 and 172, a piece of $\frac{5}{16}$-in. round iron being

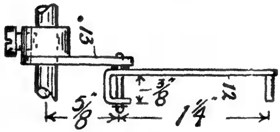


Fig. 176.—Plan of Backstop Pawl and Side Elevation of Arm which Carries it

bent and riveted into a piece $\frac{5}{8}$ in. wide and $\frac{3}{16}$ in. thick. The method of fixing is similar to that of clock No. 1.

An adjusting stop has a piece of brass tube soldered on the end of the screw to carry a felt pad. The terminals are fixed on a block of wood 14.

Half-minute Impulse Clock.—This is a half-minute impulse clock, and in the ordinary way would have a ratchet wheel of 120 teeth mounted on the centre arbor. As such a wheel would be difficult to cut by hand, a ratchet wheel of 30 teeth is substituted, and a wheel and pinion introduced to reduce the revolutions of the centre spindle to one-fourth.

The necessary wheel and pinion can be taken from the motion work on the front of an alarm-clock frame. This gearing is commonly as follows: a pinion of 12 leaves (on the centre spindle) drives a wheel of 36 teeth, and to this wheel is attached a pinion of 10 leaves, which drives a wheel (carrying the hour hand) of 40 teeth; it also drives the alarm release wheel of 40 teeth.

With these wheels there is the choice of two suitable combinations. (1) The hour wheel (40 teeth) and the pinion (10 leaves), with a ratchet wheel of 30 teeth. (2) The stud wheel (36 teeth) and pinion (12 leaves), with a ratchet wheel of 40 teeth; the latter can be made from the alarm release wheel. In Fig. 177 1 is the hour wheel, 2 the pinion mounted on the same arbor as the ratchet wheel 3.

Frame.—The front plate of the frame is 4½ in. long and ¾ in. wide (in Fig. 177 it differs slightly from the photograph); the back plate is 3 in. long and ½ in. wide, with a slight projection to embrace the ratchet-wheel pivot. The pivots and pillars are set on the centre line with the exception of the one just mentioned, which is ¼ in. from the centre line.

Having selected the wheels, the next thing is to mount them on suitable arbors, and the following hint may be useful. Take the ratchet wheel, for instance. Carefully remove its hub, and then search among the spare wheels for one with a hub having a shouldered portion which will fit the hole in the ratchet wheel; remove the old wheel and substitute the ratchet wheel.

If a hub of the correct size cannot be found choose one too large, and broach out the hole of the ratchet wheel. If the hub is not in the required position it may be moved along the arbor if great care is taken, but this step should be avoided if possible. The hole

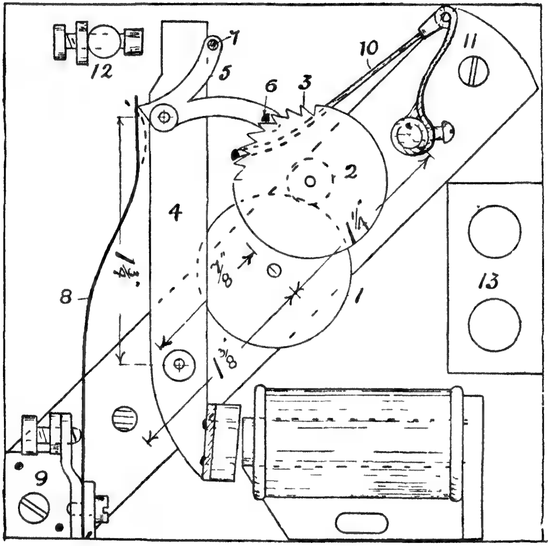


Fig. 177.—Back Elevation of Half-minute Impulse Clock (Incomplete)

in the pinion will need bushing; suitable bushing wire (fine tube) can be obtained for the purpose.

To get the pivots the correct distance apart careful measurements can be taken from the old clock. As the plates are much thicker than those of the alarm clock from which the spindles were taken, the pivot holes are more deeply countersunk on the outsides.

The 12 to 1 gear is fitted on the front, as in the other clocks.

Driving Arm, etc.—This is of thin sheet brass cut to the shape of the letter L. The long limb is 3 in. long and $\frac{3}{8}$ in. wide; the short limb is $\frac{1}{2}$ in. long, $\frac{1}{2}$ in. wide, and bent at right angles for riveting to the armature.

Armature.—This is $\frac{7}{8}$ in. long, $\frac{1}{2}$ in. wide and $\frac{3}{16}$ in.

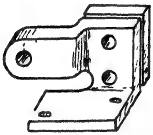


Fig. 178.—View of Fitting for Clamping and Adjusting Driving Spring

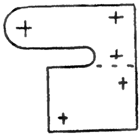


Fig. 179. — Pattern for Fitting 9

thick, and its centre line is $\frac{1}{2}$ in. below the pivot of the arm. The arm is set about midway of the arbor, and the upper end slightly "cranked" to bring the pawl 5 behind wheel 3, the object being to bring the acting parts to the rear, where their action can be seen. The general disposition of the wheels, which are shown as solid discs, can be gathered from Fig. 177.

Driving Pawl.—Part 5 is cut from thin sheet brass, and fitted with a hub to work on a stud soldered into the driving arm. The pin 6 which engages the wheel is $\frac{3}{4}$ in. from the stud, and pin 7 which projects behind the pawl is $\frac{1}{2}$ in. above the stud and about $\frac{1}{4}$ in. to

the right. Its object is to take the place of the fixed stops on the arms of the other clocks. The rear end of the pawl, where the spring meets it, should be thickened by soldering on a piece of stout brass.

Driving Spring.—Part 8, the driving spring, is about $\frac{1}{8}$ in. wide, and can be made from a corset spring —one of the narrow springs. It is supported by a special fitting 9, which is also shown in Fig. 178. The main part of this can be made from a piece of stout brass $1\frac{3}{4}$ in. square and cut to the pattern (Fig. 179).

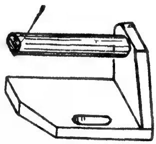


Fig. 180.—View of Magnet Frame

The bending of the upper end of the spring will require a little thought and care. If the point of application is too much above the centre of the pivot, or the bend too severe (see dotted lines), a lot of unnecessary downward pressure (and consequent friction) will be put on the pawl.

Backstop Pawl.—This is a piece of brass wire, one end of which is bent into a loop to take a pin, say a piece of knitting-needle, and the other end is soldered into a hub like Fig. 154. The arm 11 is a strip of brass about $\frac{1}{4}$ in. wide. One end is bent into a ring which will fit the pillar, and is soldered and tapped to take a set-screw. The other end is folded round

a piece of the arbor of a spare wheel, which serves as a pivot for the hub of the pawl.

Electro-magnet.—This is part of an electric bell with a cast-iron frame, from which a portion like Fig. 180 is sawn away; a slot is cut in the part which

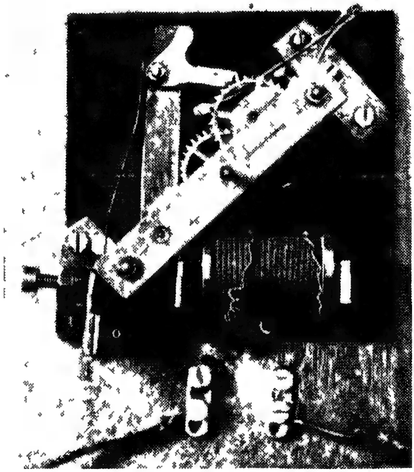


Fig. 181.--Half-minute Impulse Clock Complete

forms the base, to receive the fixing screw. It is necessary to insert a packing piece—of red fibre—under the base of the magnet to bring the pole more central and opposite the armature. The face of the armature might be given a thin coating of solder as a precaution against its sticking to the poles in case the armature and poles have not been thoroughly annealed.

The base plate is $3\frac{1}{2}$ in. square, and the frame is set at an angle of 45°.

An adjusting stop 12 can be fitted and also a block of wood 13 to carry the terminals, or the terminals may be fitted to the dial-board. Fig. 181 shows a photograph of the clock complete.

Connecting up the Clocks

The method of connecting the clocks is shown in the wiring diagram (Fig. 182), where T is the transmitter, A, B and C the terminal blocks of three clocks, D the battery, and E an anti-sparking device. It is hardly expected that the "lay-out" will be as simple as this, but the series connection shown can be carried out by noting that a wire leads from one terminal of the transmitter to a terminal of the nearest clock, from the other terminal a wire leads to the next clock, and so on, until arriving at the last clock its second terminal is connected by wire to the second terminal of the transmitter.

The battery may be placed in the circuit where shown, or at F, G and H, as may be most convenient. The anti-sparking device—a condenser or a high-resistance non-inductive shunt coil—is connected across the terminals of the transmitter.

To keep down the resistance of the circuit, thick line wires—say No. 18 or 20 bell wire—should be used, and the "runs" should be kept as short as possible.

Nothing definite can be said about the amount of

battery power required, as this depends on many things. One cell taken from a well-worn flashlamp battery will work any of the clocks described quite easily. Large-size Leclanché cells are more economical in the long run than small ones.

It must be understood that a pendulum driving the transmitting device cannot be expected to drive an ordinary electric-clock wheelwork as well, so that if a dial is required in the transmitter case, it must be of the impulse type just described.

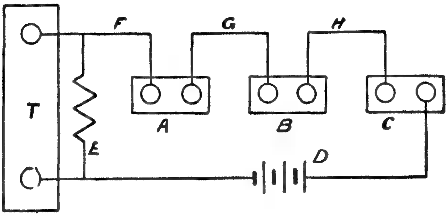


Fig. 182.—Wiring Diagram of Connections

Special Connectors.—It may not always be convenient or desirable to connect the line wires direct to the terminals inside the clock case—in the case of a mantel clock, for instance; therefore the two connectors shown in Figs. 183 to 185 may be of service. A couple of clips 1 made from springy brass are fixed near together in some convenient position on the clock, and connected to the terminals on the base plate. The line wires are connected to two strips of stout brass 2 (mounted on a piece of wood or fibre as shown), which engage with the spring clips. In Fig. 185 the clock terminals are connected to two

right-angled pieces of brass fixed back to back with a strip of fibre between them (Fig. 184). The line wires are fixed to two spring clips, which normally touch one another at the bend. When the springs embrace the angle-pieces, the current can pass through the

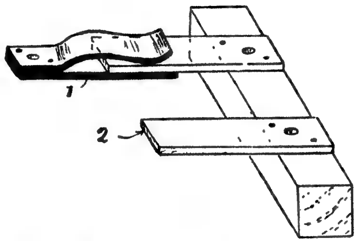


Fig. 183.—Connector and Clip

Fig. 184.—Angle-pieces

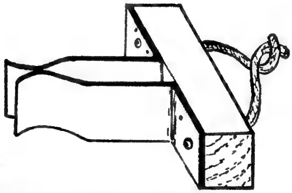


Fig. 185.—Spring Connector

magnet in the usual way; but should the clip by accident (or design) be dragged away, the springs come together and keep the circuit intact, so far as the other clocks are concerned.

A Mantel-clock Case

Fig. 186 shows a mantel clock fitted with the original works of clock No. 1. Figs. 187, 188 and 189

give scaled details of the case. It is $10\frac{3}{4}$ in. high, and the top is $9\frac{1}{4}$ in. long and 5 in. wide. The front, of $\frac{3}{4}$-in. oak, is framed up as shown. A plough groove is run up the inner edges of the side and cross pieces, and the cross pieces have a tenon on the end to fit the groove. The back wall of the groove is cut away to

Fig. 186.—Photograph of Simple Mantel Clock

form the rebate for the glass 1, which is held in by the bead 2.

The sides of the case proper are $9\frac{3}{4}$ in. long, 3 in. wide, and $\frac{3}{8}$ in. thick, nailed and glued to pieces 3 and 4. The dial-board 5, on the back of which the works are mounted, is kept in position by two pieces of wood 6 and 7 fixed with screws. The hinged back 8 is of three-ply wood. A three-ply oak mount just overlaps the edge of the rim of the dial. This mount fits in the

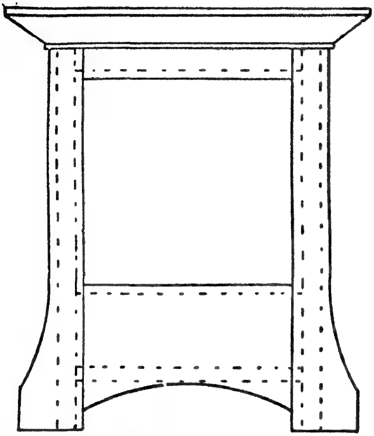


Fig. 187

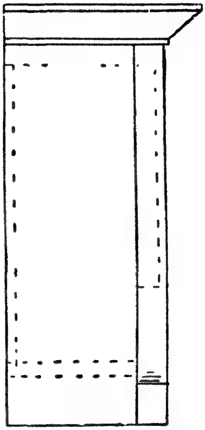


Fig. 188

Figs. 187 and 188. - Front and Side Elevations of Mantel Clock

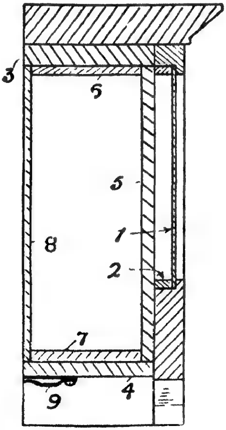


Fig. 189.—Sectional Elevation of Mantel Clock

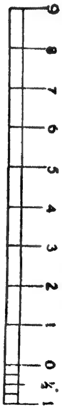


Fig. 190. - Scale of Inches

rebate, the strip 2 thus being $\frac{3}{16}$ in. narrower than shown in Fig. 189. A pair of clips 9 like those in Fig. 183 are fitted under the case as shown.

Fig. 190 represents the scale to which the case is constructed. Care should be taken to ensure that the case is dust-proof, for any accumulation of dust in the works will cause the clock to be sluggish in action and to require increased battery power.

The case of an existing clock could, of course, be pressed into service if the reader is not adept at woodworking.

CHAPTER VII

Electric Clock Chimes

A SIMPLE and easily-constructed means of controlling a series of electric hammers striking on a set of bells or rods is shown complete in Fig. 191. It is designed for use in connection with the chime release of the three-quarter-seconds clock described in Chapter II.

The driving gear, a back view of which is shown in Fig. 192, was made from an eight-day clock. On the spindle which originally carried the minute hand is mounted a metal drum studded with projecting brass pins. The pins make contact, in prearranged order, with a series of flexible brass fingers. Each finger forms part of an electric circuit in which is an electric hammer—a single-stroke electric-bell movement.

When a pin comes in contact with a finger the circuit is completed, and the hammer included in that circuit strikes one blow. Projecting from the front of the drum are four pins, which are intercepted in turn by a cranked arm (which also carries the armature of the magnet), when the drum stops and the train of wheels comes to rest.

This state of things is shown in Figs. 191 and 203, and to follow the next steps it will be necessary to refer to Fig. 83 on page 53. The electro-magnet 6 is connected to terminals 36 and 39, so that when the

clock drops arm 23, it (the magnet) is energised and draws back the cranked arm 4 (Fig. 203), thus releasing the drum and wheels. The next step is to cut off the current from the magnet by replacing arm 23 on its support. Just behind the head of the arm 4 (Figs. 203 and 204) is a flexible spring contact 8 con-

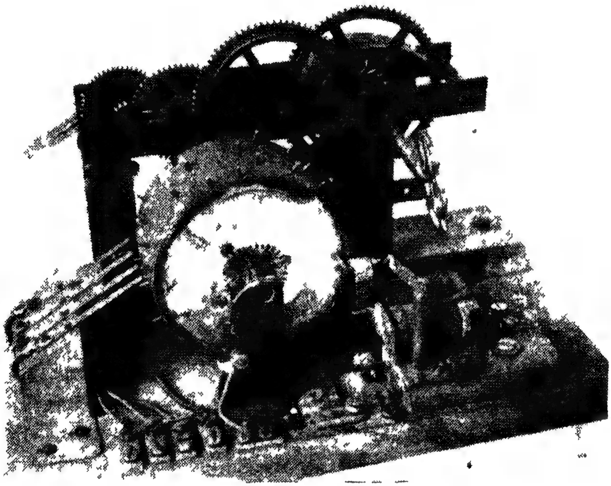


Fig. 191.—Mechanism Complete

nected with terminal 34, and the foot of arm 4 is connected with terminal 33. (It is assumed that there is a battery in this and the circuit previously mentioned.) Then when arm 4 releases the drum, it at the same instant closes the circuit of magnet 30, thus replacing arm 23. Arm 4, aided by a flat spring pressing on its foot, now falls away from the magnet, and is ready to intercept the next pin on the front of the drum.

Wheelwork. — The type of clock used may be gathered from Fig. 192. This is an eight-day striking clock; but as the only wheels required will be found in the "going" side, a strong non-striking clock would probably serve as well. Before taking the works apart, wind up the spring (or springs) and bind with a piece

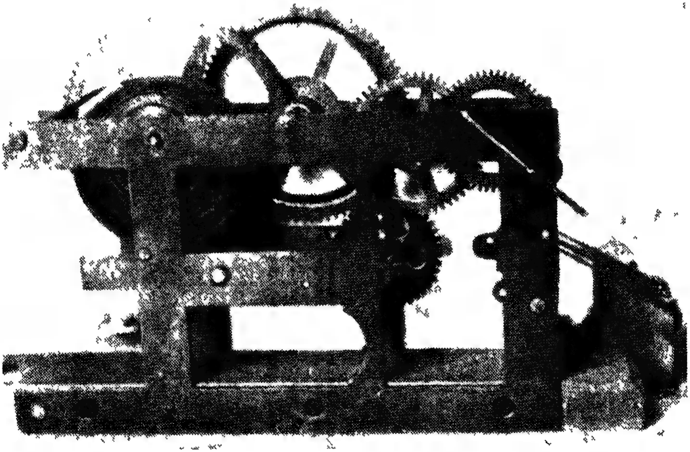


Fig. 192.—Back View of Driving Gear

of stout wire. Then let the wheels revolve until the spring wedges itself firmly in the loop, when it may be removed along with the wheel, and laid carefully aside until needed.

For convenience the wheels will be divided into two trains, the driving train consisting of wheels (and pinions) A, B, C and D (Fig. 194), and the "governing" train consisting of wheels (and pinions) E, F, G, H and J.

Wheel A (to the axle of which the spring is attached) has 84 teeth, and gears with pinion B of 7 teeth, and wheel C with 80 teeth gears with wheel (or large pinion) D of 40 teeth, so that axle I, and therefore the drum, revolves twenty-four times for each revolution of wheel A. The drum revolves once

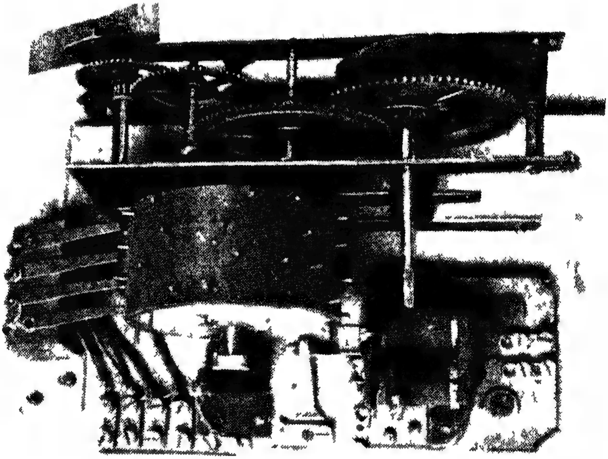


Fig. 193.—Top View of Mechanism

every hour, or twenty-four times per day. Therefore wheel A revolves once per day, so that eight effective turns of the spring will drive the drum for eight days.

Unfortunately as the spring unfolds and gets weaker, the last turns are not effective, hence with the 3-in. drum shown the spring is only effective for about six days; with a smaller drum it would drive for seven days no doubt. By removing the spring

and fixing a pulley firmly on the spindle and using, say, nine turns of cord and a suitable weight, the full run of eight days would be assured.

Only three alterations are needed to complete the works so far. The front frame needs "bushing" to suit the spindle; wheel D has to be soldered on the spindle, and a collar has to be fixed on the spindle just inside the front frame to act as a shoulder.

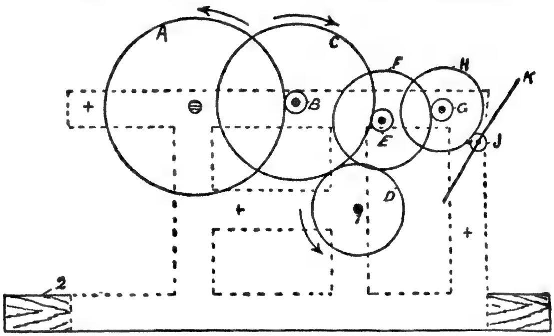


Fig. 194.- Side Elevation of Gearing

The remainder of the wheels and pinions, with the exception of pinion E, which are concerned in governing the speed of the drum are taken from an alarm clock, F being the spring wheel (54 teeth), H the centre wheel (54 teeth), with the pinion G (9 teeth) attached. J is the pinion (6 teeth) which gears with H. Wheel F is mounted on the axle which already carried pinion E (6 teeth). G and H are mounted on a spindle taken from a spare wheel. It is necessary to make fresh holes in the frame for this spindle, and their positions can be found by taking measurements from the alarm-clock frame.

To enable a good-size "fly" K to be used, pinion J is mounted on the seconds spindle of the alarm clock, and carried at the inner end by a bracket (Fig. 195), which can be secured by a small screw and two steady pins. The fly is 2½ in. long and ⅝ in. wide, but the best size can be found by trial after the drum and finger contacts are fitted. It can be fixed friction

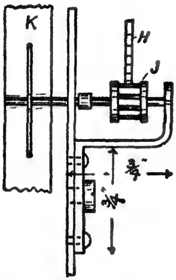


Fig. 195. — Enlarged Detail showing Mounting of Fly

Fig. 196. — Edge View of Fly

tight on the spindle (see Fig. 196) by means of a piece of wire.

A glance at a similar fly on any striking clock will show what is required. A strip of wood 2 (Fig. 194) is fitted between the frames for convenience of fixing the works to the baseboard.

Chimes.—Before proceeding to make the drum it will be necessary to decide on the chime tune, etc., that is to be adopted. Musical readers may wish to adopt an arrangement of their own, while others who

are not musical must depend on the opinion of others.

The Cambridge and Westminster chimes are set

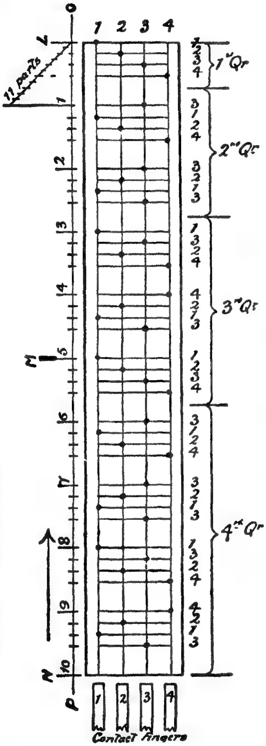


Fig. 197.—Diagram showing Setting-out of Chime Tune

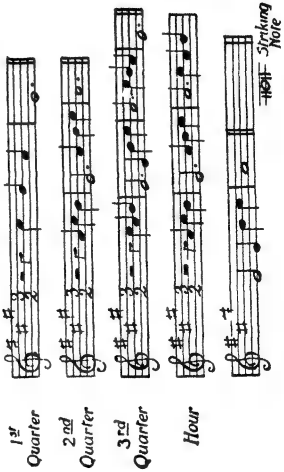


Fig. 197A.—Music for Westminster Chimes

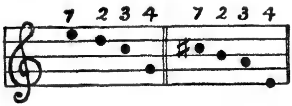


Fig. 198.—Examples of Notes for Bells or Rods

out in full in Figs. 197 and 197A. Four bells or rods are necessary. The highest (No. 1) may be any note, and the others follow at the intervals shown in Fig. 198. In the two examples given, the intervals between the

first and second bell is a tone, between the second and third bell a tone, and between the third and fourth two-and-a-half tones.

The full chime consists of 40 notes (Fig. 197) arranged in 10 peals of four notes each. One peal is rung at the first quarter-hour, two at the second quarter, three at the third quarter, and four at the hour. The interval between the peals, that is, the broad space between the short cross lines, may be two, two and a half, or three times the interval between the notes. (At Cambridge the interval is three times and at Westminster twice the note interval. Lord Grimthorpe recommends two and a half times.)

On examining the notes it will be found that the full series of chimes consists really of five peals, L to M—repeated M to N—hence it is possible to play the full series shown in Fig. 197 by means of a drum containing the first five peals only; but as it would be necessary for the drum to revolve twice in the hour, and also need a 2 to 1 gearing to operate a starting and stopping disc, this would not be a suitable arrangement with the present driving train.

Some readers might not wish to adopt quarter chimes, but might prefer half-hour and hour chimes. These might pin the barrel with five peals only; the first peal to play at the half-hour, and the four others at the hour. For this arrangement a much smaller drum would serve, or the full ten peals could be pricked (on the drum shown) and revolved once in two hours.

One other point, which is not shown in Fig. 197, may be mentioned. The space between one-quarter

chime and the next, that is, the time the gearing is at rest, may be made wider than the other intervals. (This does not apply to the drum with five peals playing the four quarter-chimes.) This extra space gives the fly more time to get up speed, and at the hour it gives room to add an extra pin (if necessary) to start the hour-striking mechanism. The music of the Westminster chimes is given in Fig. 197A.

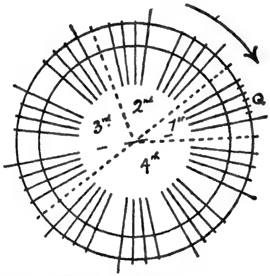


Fig. 199. – Alternative Method of Dividing Chime Drum

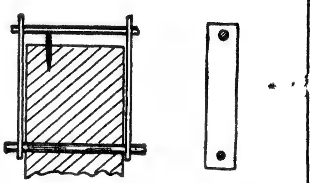


Fig. 200 **Fig. 201**

Figs. 200 and 201. Details and Application of Jig Used when Pinning Drum

Drum or Pin Barrel.—The drum 3 (Fig. 203) is 3 in. in diameter, $1\frac{1}{2}$ in. wide, and contains the 40 pins shown in Fig. 197; there is no reason why it should not be smaller in both dimensions. A smaller drum requires a little more accurate work, but the braking effect of the contact fingers is less.

A core is turned from a piece of dry mahogany to a little less than the dimensions given, and a $\frac{1}{4}$-in. hole bored through the centre. A strip of thin sheet brass, slightly wider than the drum, is fitted round

the circumference, and the joint neatly tacked and soldered. Two discs of thin brass with a $\frac{1}{8}$-in. centre hole are fitted in the ends, soldered round the edges, and the surplus metal trimmed off with a file.

The case of a Bee clock is suitable for the 10 peals, and the switch socket of an electric lamp for 5 peals, using a wooden core and metal ends in each case. Brass tube or a discarded spring-barrel might be used.

Setting Out and Pinning the Notes.—To set out the notes as in Fig. 197 it is required to know the exact circumference of the drum. Take a narrow strip of paper, wrap it round the drum, and prick a hole just beyond where it overlaps. Pin a sheet of paper on the drawing-board, draw the line O P, and set off the circumference L N and divide it into ten equal parts.

The interval between the peals is to be two and a half times the note intervals, or to get rid of fractions, the intervals are as 5 and 2 respectively. In each division there are three note intervals = 6, and one of 5 = 11. Divide the first of the ten divisions into eleven parts as in making a scale.

Having got the first division marked off, it is an easy matter to set off the remainder. Now draw the oblong, shown in heavy line, which represents a piece of paper which will exactly cover the circumference of the drum. Draw lines 1, 2, 3 and 4, which represent the track of the fingers, project the cross lines from the divisions obtained on line O P, and carefully indicate the notes by dots as shown.

The oblong can now be cut out and pasted, using

as little moisture as possible, round the drum. Indicate indelibly on the drum the direction in which it is to revolve; it may save trouble later.

Another method of working is shown by Fig. 199. On a piece of card draw a circle much larger than the drum. Divide the circumference into ten equal divisions, and then subdivide as before (see Q) and draw radiating lines. The idea is to use this card as a

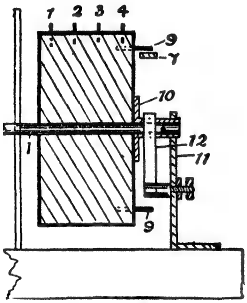


Fig. 202.—Details of Drum and Fittings

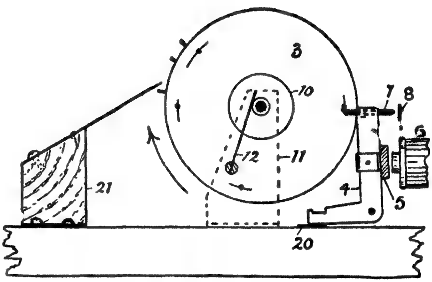


Fig. 203.—Side View of Drum, Contact Fingers, Releasing Arm, etc.

protractor to set off discs of paper to fit any size of drum which may be tried at a future time.

To use this protractor, pin it on a sheet of drawing-paper, prick through the centre and all the radiating lines. Remove the protractor, draw a circle, say the inner one of Fig. 199, equal to the diameter of the drum, and draw the lines. Cut out the circle and paste it on the end of the drum, and from the ends of the lines, square lines across the circumference of the drum. Fit a temporary axle in the drum, mount it in some convenient manner, and lightly score the

lines which represent the track of the fingers. Then, with Fig. 197 as a guide, mark the position of the notes.

Returning to the first drum round which the paper has been pasted, when the paper is dry, grip the drum by its flat sides in the vice, and punch fine centre "pops" with a fine-pointed punch, say a knitting-needle, so as to indent the brass lightly, and then remove the paper. Holes can now be drilled through the brass with an archimedian drill of suitable size.

The pins may be ordinary $\frac{1}{2}$-in. cobbler's rivets or round-headed brass nails. Cut off the head of each, and trim the end with a file. The pins should be a tight fit in the brass, and project $\frac{1}{8}$ in. or a little more.

To get the ends of the pins at an even height, that is, the same distance from the centre of the drum, some kind of guide is necessary. For this the little jig shown in Figs. 200 and 201 is useful. Two strips of fairly stout metal (Fig. 201) are bored near one end to fit a temporary axle, and near the other end to take a short length of rod which was soldered in position; the strips should rub lightly on the ends of the drum. Then with the jig in position as shown, and the drum supported in the vice, drive in the pins until the crossbar will just clear the tops.

When all the pins are in, their ends might be treated to a little grinding. If means are at hand, or can be devised, for rotating the drum rapidly, this can be done by holding an oilstone, or a piece of emery-paper glued on a block of wood, against the revolving points. The back and front of each tooth

might be filed to form a blunt wedge-shape end, taking care not to shorten them at all, so that they present a broad contact surface to the fingers, and also let the fingers fall off sooner, and so give a shorter duration of contact.

Fixing and Supporting the Drum.—The holes in the ends of the drum can now be enlarged with a reamer to fit the spindle 1 of the driving gear (see Figs. 202 and 203) friction tight. The flanged socket 10—a wheel which carried the hour hand of a spare clock and which fits the spindle—is pushed on the spindle while the drum is in position, and soldered to the face of the drum. A hole is bored through the tubular part opposite the hole in the spindle, the hole which had been provided for the pin which kept the minute hand on.

Later, when all is ready for fixing, a pin can be fitted in to hold the drum.

A bracket 11 serves to support the drum, and also carries the continuous-contact spring 12. The latter is a strip of thin springy brass soldered in a saw-cut in the end of a short pillar made from the bell pillar of an alarm clock. The long screw of this pillar provides a ready means of connecting a wire to the contact.

The pillar is fixed at such a height that it does not interfere with pins 9, and the spring is just sufficiently long to rub nicely on the socket of 10. Possibly the spindle 1 may not be long enough to admit of this arrangement

The main consideration is to fix the drum, then

if the tube of 10 overlaps the end of the spindle, it might turn on a short pin soldered in the supporting bracket 11.

The drum might be made narrower in the first instance; the contact spring might be applied to the spindle at some place between the frames, soldering a brass collar on the spindle for it to rub on.

Releasing Magnet.—Particulars of the releasing magnet may be gathered from Figs. 203 to 207. The bobbins and yoke 6 may be taken from an electric bell, and screwed to a block of wood about $2\frac{3}{4}$ in. square and $\frac{1}{2}$ in. thick, and provided with slots for adjustment. Screwed to the end of the wood, about 1 in. apart, are two brackets 13 to carry the axle of arm 4. Arm 4 is of stout brass about $\frac{5}{16}$ in. wide. It may be cut from the sheet or built in two parts, the foot being about 1 in. long.

Collars are soldered on each side to keep all firm and steady. The upper end is bent over at right angles (see Fig. 206), and to this is attached the piece of iron or steel 7. This strip may be $\frac{5}{8}$ in. or $\frac{3}{4}$ in. long, $\frac{1}{4}$ in. wide and $\frac{1}{8}$ in. thick, shaped as shown, and with a silver contact point soldered on the rear end. The top of this piece should be just a shade below the centre line of the drum (see Fig. 203).

The armature 5 is fixed to the arm, by a strap of thin brass, just opposite the magnet poles (see Fig. 205). A piece of thin springy brass, shaped somewhat like 14, presses on the foot of arm 4, to ensure that the armature drops away from the poles when the current is cut off. It should not be stiffer

than necessary, and if the armature shows a tendency to stick to the magnet poles, the face of the armature should have a piece of paper pasted on.

A piece of broad watch-spring soldered to a plate

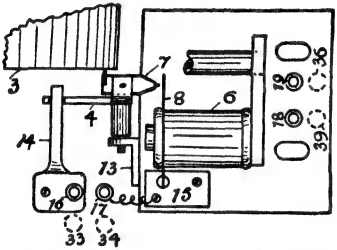


Fig. 204.—Details of Releasing Magnet, etc.

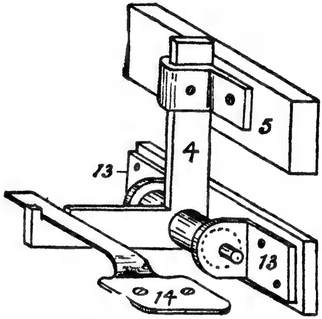


Fig. 205.—Parts of Releasing Magnet

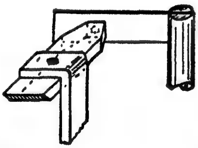


Fig. 206.—Parts of Releasing Magnet

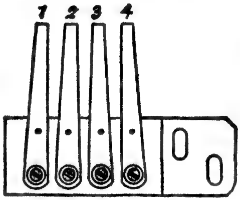


Fig. 208.—Contact Fingers

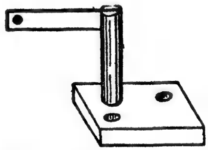


Fig. 207.—Method of Building-up Contact Spring

of brass would serve for this spring, starting with a blade about 1½ in. long and shortening it until the right stiffness is obtained.

The contact spring 8 may be of brass or watch-spring with a tip of silver soldered on opposite the point of 7. A pillar fixed to a brass plate 15 (some-

thing like Fig. 207) supports the spring at the proper height. For the present it is only necessary permanently to fix the arm 4 and its fitting; the position of the magnet, etc., can be best found by trial later on.

Contact Fingers.—These are of springy brass about $2\frac{1}{4}$ in. long, $\frac{1}{4}$ in. wide at the broad end, and $\frac{1}{8}$ in. wide at the narrow end. A certain amount of experimenting will be necessary here to get the best effect.

The fingers may need hammering to make them harder and more springy, or filing to make them more flexible. If too stiff there is unnecessary braking, and if too weak the contact may be poor. They are fixed, by a fine pin and a small screw for connecting the wires, to a block of wood 2 in. long and 1 in. thick, and are inclined at an angle of 30° with the base, so that they meet the pins a little above the centre of the drum. To the base of the block 21 is fitted a strip of metal, with slots for screws to allow for backward and forward adjustment (Fig. 208).

Alternative Device.—A more efficient make-and-break is shown in Figs. 209 to 213. Although more troublesome to make, it is well worth the extra time spent, as the contact is more certain and the duration of contact is considerably reduced, with a consequent saving of battery power.

The device is simply a modification of the contact-closing device of the electric clock. Four flexible springs, soldered to one common foot, stand in front of the four rows of pins in the drum. On the face of

each spring is soldered a small metal block to intercept the pins, so that a pin must push back the spring before it can pass, and this causes the upper end of the spring to make contact with a contact screw supported at a suitable height to meet it.

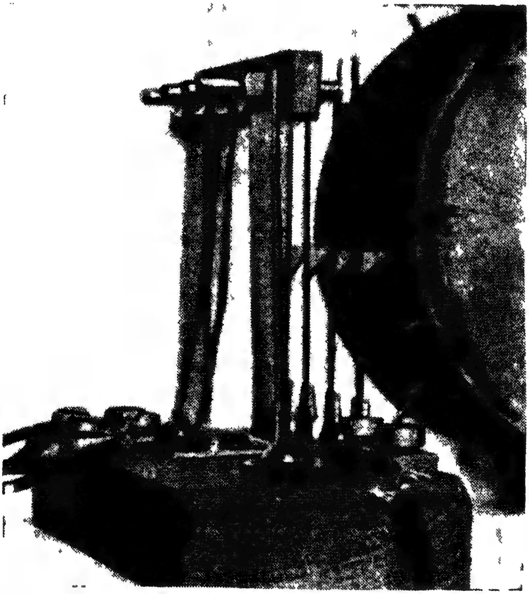


Fig. 209.—Alternative Arrangement of Contact Fingers

The wires to the bells are connected to the four contact screws—or to intermediate terminals fixed on the base—and the common lead (or return) wire is connected to the foot to which the springs are soldered. It will be seen that the drum and pins do not, as in the previous device, form part of the circuit; the pins

simply play the part of the trigger in the clock contact.

Base.—This is a piece of dry mahogany 3 in. long, $1\frac{1}{2}$ in. wide and $\frac{1}{2}$ in. thick. The extra length at the right-hand end of Fig. 211 is to allow for a slot and

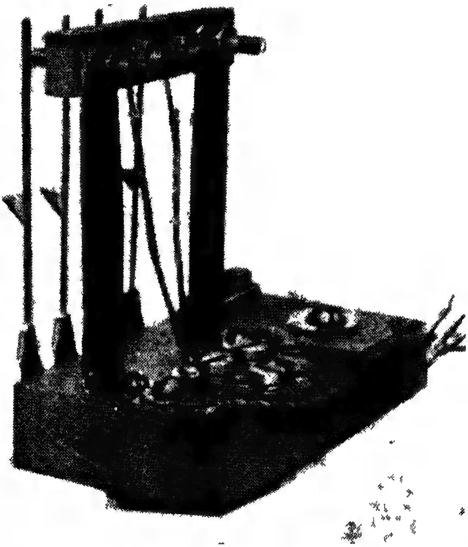


Fig. 210.—Another View of Contact Fingers

holding-down screw; the slot allows for adjusting the depth the pins and blocks engage.

Contact Springs.—In Fig. 213 an endeavour has been made to show the various stages of construction in one diagram, and the following suggestions may be useful.

Across a piece of board square four lines, shown

in chain-line, the same distance apart as the pin circles of the drum. Clean up a piece of thin brass about $2\frac{1}{2}$ in. long and $\frac{3}{4}$ in. wide, and coat a strip, about $\frac{1}{4}$ in. wide, along one edge with a thin layer of solder. Set out and punch the holes—about $\frac{3}{16}$ in. in diameter—cut out the little wedge-shape pieces, and then fold up the edges to form a kind of bed in

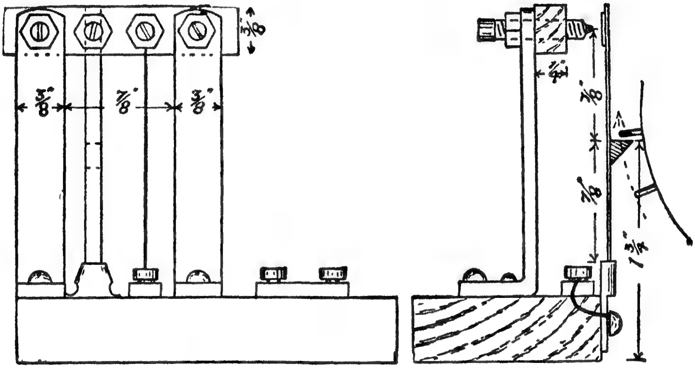


Fig. 211 Fig. 212

Figs. 211 and 212.—Elevations showing Standards, Contact Screws, etc.

which the spring can lie, keeping the bottom of the bed flat. Tack the brass to the board in the correct position, and lay the springs in place, tacking a strip of wood across them to keep them from shifting.

The little turned-up sides can now be folded over the spring as tightly as possible, and the lot soldered. Watch-spring or spring brass can be used as desired. This method of fixing the springs, if more trouble, is certainly stronger than simply soldering them on.

Each spring, it will be noted, is soldered to a

separate "tab," and if the faces of the little blocks are not in line, they can be adjusted backwards or forwards by bending the neck of the tab.

The little blocks may be of steel, iron or brass. A length of metal is filed up to the required section—half a square with $\frac{3}{16}$-in. sides—and four pieces sawn off with a fine saw. There is no harm in the blocks being smaller; but if made too large and heavy the spring may vibrate to such an extent that false contacts might be made after the proper contact had been broken. If the strip of wood be in the position shown, it will form a guide for soldering on the blocks.

The parts can now be taken off the board, the surplus metal cut away, and strips of silver—it would probably be useless to suggest platinum—soldered on the backs of the springs near the tips.

Contact Screws.—These are four $\frac{1}{8}$-in. screws about 1 in. long and without a head, and are provided with a nut and tipped with silver. A piece of fibre or hard wood, say box or pear, can be tapped to receive them. Two supports of stout brass carry this bar at the correct height, the contact screw and its nut serving to bind them together.

The two inner contact screws have each a piece of copper wire—it may be bare—clamped under the nut and led to a suitable terminal on the base. The two supports serve the same purpose for the outside contact screws. Another terminal is fixed on the base, and a wire led from this to the foot of the springs (see Fig. 212). The illustrations are purposely incomplete

In the previous make-and-break, contact took place

when the pins were at or about centre height. With the present one, contact should be made a little before —say ¼ in.—the centre line is horizontal, hence the position of the stop pins on the face of the drum will not be in exactly the same position as they were for the previous contacts.

As before, the best positions for the stop pins can be found by trial. When the drum is released it gives

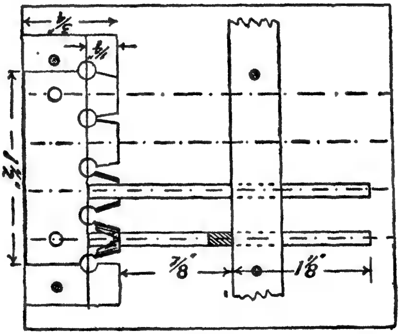


Fig. 213.—Diagram showing Setting-out and Construction of Spring Contacts

a short jerk forward. This is a good feature, inasmuch as it ensures the pin moving clear before the stop can return; but there is the danger, unless sufficient space is allowed, of the first pin of the oncoming peal closing the circuit before time, hence the stop pins should be arranged to stop the drum the instant the last pin of the peal has cleared the block.

Assembling the Parts.—The various parts might be assembled temporarily at first. Fix the wheel-work with the drum in position, also bracket 11, then

support the point of a scriber in some convenient manner, and scribe a circle on the face of the drum about $\frac{3}{16}$ in. from the edge; on this circle the stop pins 9 will be set.

Now fix the releasing magnet (so far as completed) in the position shown in Figs. 203 and 204; only a portion of the drum is shown in the latter figure. It will be noted from Fig. 203 that arm 4 has just the slightest forward tilt; a piece of metal 20 of suitable thickness can be inserted under the foot to regulate this. The corner of piece 7 is set opposite the circle and about $\frac{1}{8}$ in. from the drum. This is illustrated in Fig. 202, where piece 7 is supposed to have been lifted up.

The contact fingers are next set to engage the pins. Now find by trial the best position for the stop pins 9.

The point wished to aim at is to stop the drum the instant the last pin of the chime has broken contact, so that when the drum is released for the next chime the wheels will have the longest possible run, and so get up speed, before the fingers again make contact and, as it were, put the brake on.

Wind the spring just sufficiently to turn the drum, and run the first chime. The instant the last pin clears the finger, stop the drum and put a pencil dot above 7 where the pin is to be; run the other chimes and do the same. Try this two or three times to check the pencil dots.

The drum can now be removed, and suitable holes bored with an archimedean drill to take the pins—

round brass nails or gramophone pins—which project $\frac{1}{4}$ in.

If the pins have been accurately set, a very short movement of arm 4 will liberate the drum. The edge of piece 7 need only reach to, or a hairbreadth beyond, the centre line of the pin.

The bobbins can now be fixed to allow just the necessary movement of the armature, and contact spring 8 fixed so that the tip of 7 is nearly touching it. The bobbin wires are fastened to terminals 18 and 19 (Fig. 204), and two other terminals 16 and 17 and fitted where shown. Four terminals can be fixed in some convenient position, and connected by wires to the four fingers; a fifth terminal is connected up to spring 12.

The dotted circles in Fig. 204 represent the terminals of similar number in Fig. 83. Magnet 6, it will be noticed, is energised when the clock closes the circuit. The result would be just the same, of course, if terminal 19 was connected to 39 and 18 to 36; and the same remark applies to the two other pairs of terminals.

Things are now in a better position to trace the various actions. When the clock closes the circuit, magnet 6 pulls back arm 4 and the drum starts to revolve. At the same instant the point of 7 makes contact with spring 8, so that current can pass from a battery to, say, terminal 17, to plate 15, along spring 8, down arm 4, along spring 14 to terminal 33, thence through the magnet 30 (Fig. 83) to terminal 34, and back to the battery. The energising of magnet 30

replaced arm 23 (Fig. 83) and broke the circuit of magnet 6, and arm 4 falls away to intercept the next stop pin.

Now follow the electric-hammer circuit. The contact fingers are connected in proper order to each hammer, numbered 1 to 4 to correspond. A wire leads from finger 1 to one end of the wire of the magnet of No. 1 hammer, and so on with the other fingers. This leaves a free wire for each hammer magnet to be connected to a common terminal.

From this terminal a wire, which thus acts as a common lead or return wire for the four magnets, is led to a battery, and this battery is connected with spring 12. Now when finger 1 comes in contact with a pin, current can pass, say, from the battery along spring 12 to the drum casing, along the pin and finger 1 to the magnet of hammer 1, and back by the common wire to the battery.

It will readily be seen that dirty or imperfect contacts may easily lead to a breakdown. Springs 12 and 14 should have special attention, and the pins in the drum should make good contact with the metal casing.

The battery power required will depend on various circumstances. A common battery of 2-qt. Leclanché cells to work the magnet 30 (Fig. 83), and magnet 6 will probably answer. The two cells are connected with the former and one of them with the latter. This arrangement may not work in all cases, from causes which cannot be gone into here, so it may be necessary to employ two separate batteries.

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